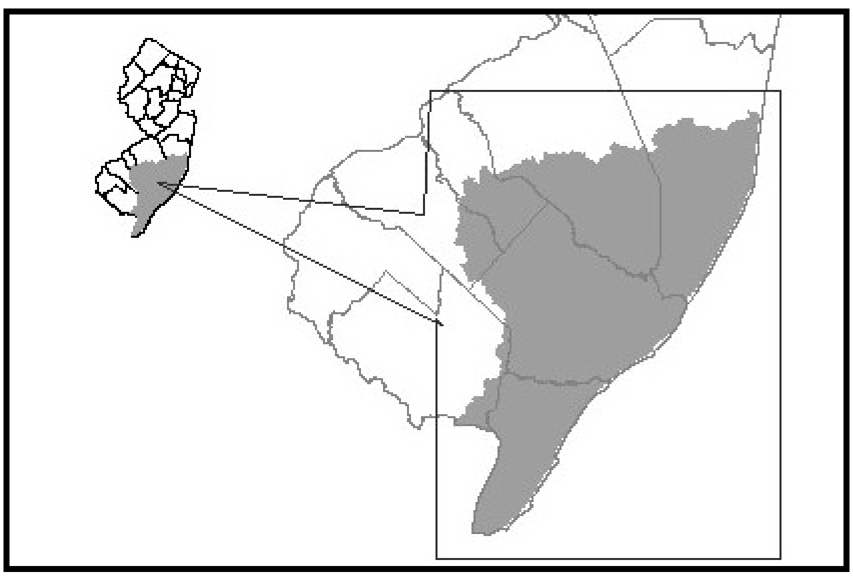
NEW JERSEY

DEPARTMENT OF ENVIRONMENTAL PROTECTION

LAND USE MANAGEMENT
DIVISION OF WATERSHED MANAGEMENT

DRAFT

STATUS OF THE WATER SUPPLY OF SOUTHEASTERN NEW JERSEY



SOUTHEASTERN NEW JERSEY STUDY AREA

SEPTEMBER 25, 2003

STATUS OF THE WATER SUPPLY OF SOUTHEASTERN NEW JERSEY

SEPTEMBER 2003

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STATUS OF THE WATER SUPPLY OF SOUTHEASTERN NEW JERSEY

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FOREWORD

Executive Order 32 and subsequent actions required the New Jersey Department of Environmental Protection (NJDEP) to “assess the adequacy of the water supply in relation to approved and anticipated growth in Egg Harbor, Galloway and Hamilton Townships” in consultation with Atlantic County, the Pinelands Commission, the New Jersey Department of Community Affairs, Rutgers The State University, the State Climatologist and the United States Geological Survey. This Executive Order was effectuated due to uncertainties regarding the adequacy of the water supply of the region to support the substantial growth that was occurring in these municipalities. This Status of the Water Supply of Southeastern New Jersey report fulfills the above requirement.

This report evaluates water supply issues associated with the withdrawals from the above municipalities, as well as those for the region with which these municipalities share their water supply, and describes approaches to address them. The water supplies that are withdrawn in Egg Harbor, Galloway and Hamilton townships are not “independent” resources; rather, these townships share the more expansive regional supply of Southeastern New Jersey. This regional supply consists of the deep confined Atlantic City 800-foot sand aquifer from Cape May to Ocean County, and the shallow unconfined Kirkwood-Cohansey water table aquifer in the Great Egg Harbor River, Mullica River and Southern Barnegat watersheds. This report examines this regional supply.

Based on this report, the NJDEP has concluded that this region will experience both immediate and long-term problems associated with its water supply. Among the more immediate problems are streamflow depletion as a result of surface water withdrawals and ground water withdrawals from the water table aquifer. The long-term problem is the migration of saltwater into the deeper aquifer systems in Cape May County, and possibly in Ocean County. In both cases, the fundamental problem is that most of the water withdrawn from these resources is not being returned to them after use. Additional development in the region will exacerbate these problems. Compounding these circumstances are threats to the quality of the drinking water supply in the water table aquifer system.

The NJDEP will consequently require that a comprehensive water supply plan be developed in Southeastern New Jersey, and that this plan be integrated into a holistic “Intelligent Growth” strategy to effectively protect and sustain the natural resources of the region. The NJDEP shall initiate the water supply plan in the very near future. This report can serve as the basis for the plan. Affected stakeholders will be invited to participate in the development of this plan.

Since it will take some time to develop and implement this comprehensive strategy, an interim strategy to ensure that the current problem is not unduly exacerbated will be implemented in the region. The major theme of this interim strategy would be to preserve the potable water supplies of the region for public health and safety needs. The NJDEP will implement this strategy in coordination with the region’s stakeholders.

Effective upon formal release of this report, the first step that the NJDEP will take to implement this strategy will be to elevate its current policy of using lower quality water for new or expanded non-potable (non-essential), consumptive uses of surface water or ground water in the Southeastern New Jersey region. This policy will cover all new or expanded withdrawals from the region's resources for non-potable water uses such as those for lawn and landscape irrigation, industrial cooling, golf courses, etc. No new water allocations for these uses will be permitted where alternative sources of water are available. The NJDEP will require the beneficial reuse of wastewater for new or expanded non-potable, consumptive uses, unless an assessment concludes that reuse is cost- or environmentally-prohibitive.

Where an assessment concludes that reuse is inappropriate, applicants will be required to implement a reduction proportionate to the amount being requested from an existing user from the same resource. For example, an applicant for a non-essential withdrawal could coordinate with an existing non-essential user so that the latter could switch to an alternative source, such as beneficial reuse where the existing user is in a better position to take advantage of reuse. This could be the case when the existing user is in closer proximity to a regional wastewater treatment plant so that infrastructure and treatment costs can be minimized. Or the existing non-essential users could implement a water conservation plan equivalent to the amount needed by the new non-essential user so that there would be no net increase in non-potable use. The NJDEP will investigate the potential of effectuating a strategy where existing allocations can be acquired by new users when the former substitutes non-potable water for potable water, or implements conservation measures so that a new use can be permitted. The NJDEP will also consider other innovative approaches to conserve the potable supply of the region.

Concurrent with the above, the NJDEP will collaborate with the Boards of Chosen Freeholders and municipalities in the Southeastern New Jersey region to implement the mandatory year-round conservation of potable water. As described in this report, summertime water use is substantial in the region; peak summertime water use is twice or more of that used during the winter in several municipalities. The NJDEP will work closely with the region's stakeholders to implement mandatory water conservation measures such as the installation of rain and moisture sensors on automatic lawn sprinkler systems and drought tolerant landscaping, implementation of odd/even watering days, maintenance of aquifer recharge initiatives, and other appropriate measures to conserve the potable supply.

Further, until the comprehensive study is completed, the NJDEP will prohibit most new withdrawals and expansions of existing supplies from the Kirkwood-Cohansey water table aquifer. During this interim period, most new withdrawals will be required to use the Atlantic City 800-foot sand aquifer or other deeper aquifers. As described in this report, while saltwater intrusion is problematic in this deeper aquifer, existing wells are not anticipated to be affected until well into the future. As also described, wells currently using the water table aquifer are likely impacting aquatic resources due to the impact that these withdrawals have on stream baseflow and other environmentally-sensitive low flows. While wells in the deeper aquifer do indeed affect baseflow, their withdrawal effects are spread out over large areas; consequently their impacts are not as acute as those that directly withdraw from the water table aquifer. This policy is consistent with the Pinelands Comprehensive Management Act.

The NJDEP may make exceptions to the above under certain circumstances. This would be when new wells in the deeper aquifer might significantly accelerate saltwater intrusion. In general, this would be limited to southern Cape May County (southerly of Stone Harbor) and possibly in Ocean County where there is limited understanding of the location of the saltfront. In addition, the NJDEP will consider innovative withdrawal approaches such as the seasonal conjunctive use of the water table aquifer and the confined aquifer.

Last, it will also take some time to develop a comprehensive drinking water protection plan for the Southeastern New Jersey region. A review of the well head protection areas of the region's public wells indicates that there is a significant number of existing potential contamination sources within these areas. In addition, there is substantial growth potential within these areas that could possibly increase the vulnerability of these wells. The NJDEP will coordinate with local stakeholders during this interim period in an effort to ensure that these supplies are adequately protected.

The NJDEP is committed to working with the stakeholders of the Southeastern New Jersey Study Area to initiate an interim strategy that would reduce the effects of new development on water quality and aquatic resources, as well as to coordinate the development of a regional water supply plan that would ensure that the integrity of the region's water resources is maintained over the long term.

ACKNOWLEDGEMENTS

The New Jersey Department of Environmental Protection would like to extend its appreciation to the individuals listed below for their efforts and contributions toward ensuring that southeastern coastal New Jersey continues to possess an adequate water supply:

PROJECT COORDINATORS

Atlantic County Planning Department

Atlantic County Utilities Authority

Pinelands Commission

United States Geological Survey

Department of Community Affairs

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STATUS OF THE WATER SUPPLY OF SOUTHEASTERN NEW JERSEY

1.0 BACKGROUND

The southeastern coastal region of New Jersey is largely dependent upon two ground water resources: 1) the shallow, unconfined Kirkwood-Cohansey (water table) aquifer, and 2) the deeper confined Atlantic City 800-foot sand aquifer. Withdrawals from these water supplies have significantly increased over the last several decades and are now stressing these resources. Below is a chronological description of events and initiatives that led to the development of this report.

1.1 HISTORY

The 1982 NJ Statewide Water Supply Master Plan (the 1982 Plan) identified Atlantic City and 13 nearby coastal communities (hereon referred to as the Atlantic County Study Area) as an area with potential water supply problems as a result of the substantial growth this area has recently experienced, as well as that expected in the decades to come. The primary concerns identified in the 1982 Plan were the potential for: a) saltwater intrusion that could impair barrier island and near-shore wells in the Atlantic City 800-foot sand aquifer; b) ground water contamination of the water table aquifer; and c) reductions in stream flow as a result of pumpage from the Kirkwood-Cohansey water table aquifer.

The first revision of the 1982 Plan, Water for the 21st Century: The Vital Resource – New Jersey Statewide Water Supply Plan (the 1996 Plan) evaluated the water supply status of 23 of the State's largest watersheds. This effort identified the Mullica River watershed to be in an estimated current water supply deficit due to potentially excessive agricultural and potable supply withdrawals from surface water and the unconfined Kirkwood-Cohansey aquifer in the watershed. The 1996 Plan also projected that the Great Egg Harbor and Atlantic Coastal (Southern Barnegat Bay) watersheds would be in water supply deficit in the decades to come based on anticipated new development. It also identified the Cape May Coastal watershed as a saltwater intrusion concern. All of these watersheds share a regional water supply. The Atlantic County Study Area discussed above is in the Mullica and Great Egg Harbor watersheds.

The 1982 Comprehensive Pinelands Preservation Plan identified several growth areas as a means of preserving the natural resources of the core of the Pinelands. Among the municipalities identified for growth were Egg Harbor, Galloway and Hamilton townships in Atlantic County. Development over the last two decades within these three townships has been substantial. The New Jersey Department of Environmental Protection (NJDEP) has recently questioned whether there is ample water to support this rate of growth for these municipalities. During the severe drought of 2002, an Executive Order (Number 22) was established on September 22, 2002 that imposed restrictions on these three towns from tying into the water supplies of the region and on the issuance of new well permits.

An Administrative Order (Number 32) simultaneously required the NJDEP, in coordination with other related parties,[1] to assess the adequacy of the water supply for the three municipalities. This report fulfills that requirement and represents a collective evaluation of the water resources that these municipalities "share" in the region or are otherwise interconnected with (and thus may affect). This region is hereinafter referred to as the Southeastern New Jersey Study Area. See Section 2.1 in this report for a description of the study area.

1.2 OBJECTIVES OF THE REPORT

The primary objective of this report is to present the current and projected status of the water supplies of the Southeastern New Jersey Study Area, which includes Egg Harbor, Galloway and Hamilton townships as required by Executive Order 32. These three townships share their supply with that of the region. This report draws its conclusions from previous investigations of the region's water resources, and also makes a range of interim and long-term recommendations, presented in Section 7.0 in this report, that are capable of addressing the more serious water supply problems of the region.

The NJDEP has recently made the transition from employing permit-driven processes to protect and restore water quality, water supplies and natural resources to a more integrated, holistic approach that focuses on Intelligent Growth in a watershed to meet these objectives. This report emphasizes that approach, which relies on stakeholder participation in order to be successful.

This report will serve as one of the many sources of information that the NJDEP and other State agencies employ to make regulatory and policy decisions, in conjunction with other more site-specific data.

1.3 PREVIOUS INVESTIGATIONS IN THE REGION

This section describes the numerous documents and investigations that were used in preparing this report and reaching its conclusions.

First, to address the concerns identified in the 1982 Plan, the NJDEP in cooperation with the United States Geological Survey (USGS) initiated an investigation of the principal ground water resources of the Atlantic County Study Area. The objectives of this investigation were to: 1) define the extent and magnitude of saltwater intrusion in the Atlantic City 800-foot sand aquifer under various demand scenarios from 1990 to the year 2040; 2) evaluate alternative solutions that would minimize the effects of saltwater intrusion and allow for a sustainable resource; 3) assess the potential for streamflow reductions as a result of depletive and consumptive withdrawals[2] from the water table aquifer; and 4) evaluate the quality of the region's water table aquifer resources.

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[1] New Jersey Department of Community Affairs, Pinelands Commission, Rutgers The State University, State Climatologist, USGS, and Atlantic County.

[2] In this report a depletive or consumptive withdrawal is defined as the use of water from a source in such a manner that it is not immediately returned to the same source. An example of a depletive use is the out-of-basin transfer of water by regional wastewater systems that discharge sewage to the ocean. Examples of consumptive uses include evaporative losses of water in agricultural and residential/commercial irrigation.

Second, as a component of the overall investigation, a water supply alternatives evaluation was contracted by the NJDEP to the URS Company in association with R.E. Wright Associates, Coopers & Lybrand, and Environmental Testing & Certification.

Third, while defining the magnitude of the problem, it was learned that the Atlantic City 800-foot sand aquifer in southern Cape May County would be affected by saltwater intrusion before the Atlantic County Study Area. In consideration of this, and the fact that southern Cape May County was also presently experiencing saltwater intrusion in other regional aquifer systems, an investigation of Cape May County's ground water supplies was initiated by the NJDEP and USGS. Affected users in southern Cape May County have begun to comprehensively address that more immediate problem.

Fourth, the 1996 Plan employed planning thresholds for withdrawals in the major watersheds of the State in order to determine the potential for significant regional impacts. The planning period for this initiative was also from 1990 to 2040. Based on the thresholds utilized and demand estimates made at the time, this plan tentatively concluded that the Mullica River watershed may presently be in a potential water supply deficit, and that the Great Egg Harbor River and Southern Barnegat Bay watersheds might be approaching potential deficit conditions within the planning period.

Fifth, the 1982 Pinelands Comprehensive Management Plan, as mentioned in Section 1.1, was utilized in this report, since it includes three municipalities that are in the Southeastern New Jersey Study Area.

2.0 PHYSICAL SETTING

Below is a description of the original Atlantic County Study area and the expanded Southeastern New Jersey Study Area.

2.1 STUDY AREA AND REGION

The original Atlantic County Study Area encompassed the following eastern Atlantic County municipalities. The 1982 Plan identified this area as having the potential threat of saltwater intrusion that could impair wells in the deep confined Atlantic City 800-foot sand aquifer in the future (see Figure 1).

Absecon	Galloway	Pleasantville
Atlantic City	Linwood	Port Republic
Brigantine	Longport	Somers Point
Egg Harbor City	Margate	Ventnor
Egg Harbor Township	Northfield	

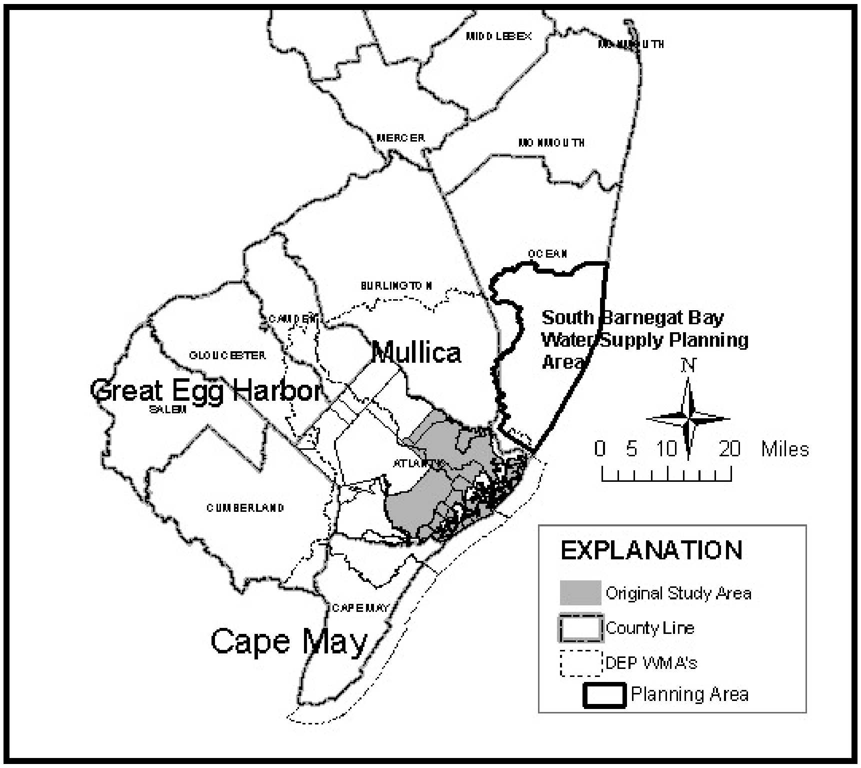

Figure 1. Location Map of the Municipalities within the Original Atlantic County Study Area, as Recommended by the 1982 NJ Statewide Water Supply Master Plan

The 1996 Plan concluded that Mullica River watershed is in a present estimated water supply deficit, and projected that the Great Egg Harbor River watershed would be in a planning deficit in about Year 2040, as detailed in Section 1.1 earlier. The original Atlantic County Study Area is located within these two watersheds. In addition, it was recently determined in a comprehensive ground water investigation that while saltwater migration was not an immediate problem in Cape May, steps should be taken by the users of this resource to preserve their water supply (NJDEP, 2003). Last, in 2002 Executive Order 32 required that the NJDEP assess the adequacy of the water supply in Egg Harbor, Galloway and Hamilton townships. A larger framework was needed that would take into account the interrelationship of these water resources of the region.

Thus, the original Atlantic County Study Area was incorporated into this report's study area, the Southeastern New Jersey Study Area (see Figure 2 below).[3] This study area consists of the Atlantic County Study Area; the water table aquifer in the four watersheds: Mullica River, Great Egg Harbor River, Cape May Coastal and Southern Barnegat Bay (previously referred to as the Atlantic Coastal), as well as the surface waters that originate in these watersheds; and the deeper Atlantic City 800-foot sand aquifer in Ocean, Burlington, Atlantic and Cape May counties and its recharge area. The

[3] The Study Area may be slightly refined when the comprehensive Water Supply Feasibility Study is being scoped out to take into consideration factors such as a more precise delineation of the Atlantic City 800-foot sand aquifer's recharge area, the effects of pumpage, etc.

municipalities in the Southeastern New Jersey Study Area are provided by watershed along with their Year 2000 population in Appendix A.

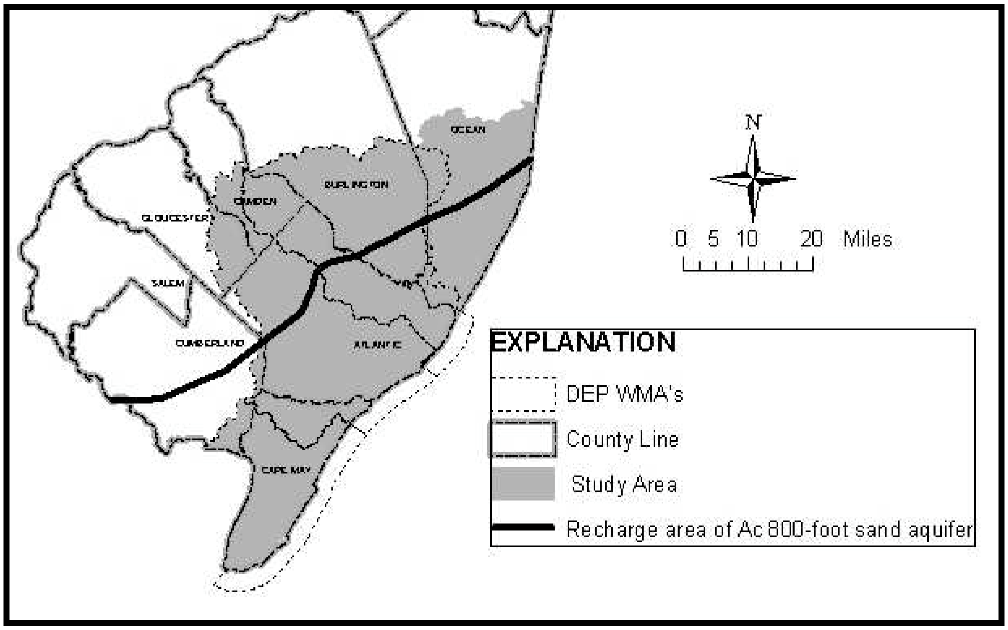

Figure 2. Location of the Expanded Southeastern New Jersey Study Area, as Recommended by this Report

Withdrawals and other activities in this larger Study Area could potentially have adverse effects in the Atlantic County area, and vice versa. For example, surface water diversions for agricultural use in the headwaters of the Mullica River and its tributaries can result in streamflow depletion. This reduction in streamflow can be exacerbated further downstream where water is withdrawn from the shallow water table aquifer and used for residential and commercial purposes, and ultimately discharged into the ocean via regional sewerage systems. Or, withdrawals from the Atlantic City 800-foot sand aquifer in Ocean and Atlantic counties can contribute to ground water level declines in Cape May County, and accelerate saltwater intrusion in that area. Consequently, this report addresses this entire region as the Southeastern New Jersey Study Area.

3.0 WATER RESOURCES OF THE REGION

There are three primary sources of water in the Southeastern New Jersey Study Area that are substantially interconnected. There are other secondary sources of water, but these are not utilized to a large degree. Figure 3.a provides a simplified cross-section of all of Southern New Jersey's major ground water systems. The Southeastern New Jersey Study Area is approximately represented by the right half of Figure 3.a.

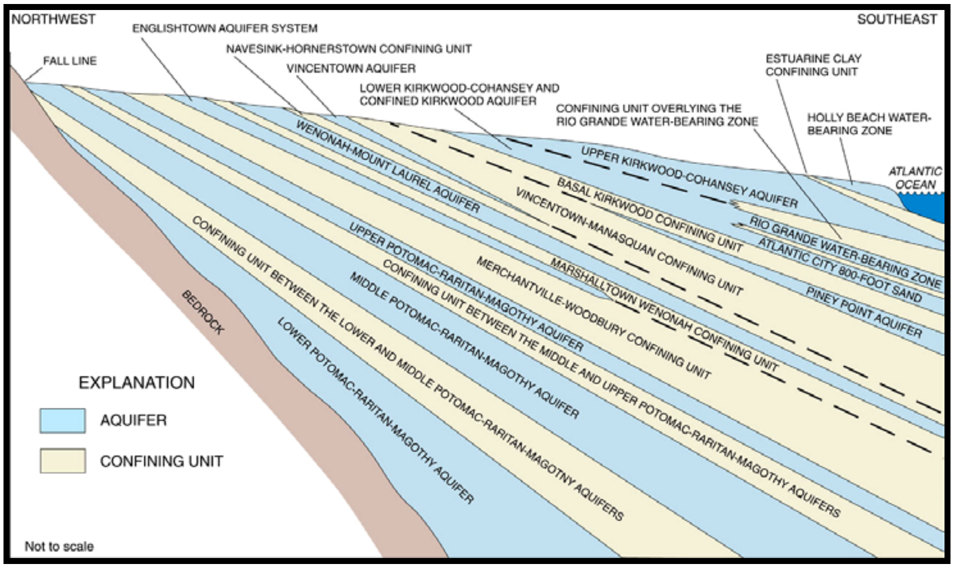

Figure 3a. Cross-section of the Aquifers of the Southeastern New Jersey Study Area

First, there is the Upper Kirkwood-Cohansey water table aquifer that underlies the four watersheds of the Southeastern New Jersey Study Area. The primary source of water for this aquifer is precipitation that infiltrates as recharge; most of this recharge occurs at the higher elevations within each of the watersheds. Second, there are the streams and rivers of these watersheds. Flow in these water bodies is primarily the result of ground water discharging from the water table aquifer. Thus, there is a very close hydraulic connection between surface waters and the water table aquifer (i.e., the water table aquifer and surface water within the watershed are essentially the same resource). Third, there is the deep confined aquifer, the Atlantic City 800-foot sand aquifer. The natural source of the majority of water in the Atlantic City 800-foot sand aquifer is the recharge from where it is interconnected with the Kirkwood-Cohansey aquifer in western Atlantic, and Cumberland, Burlington and Ocean counties (see Figure 3.b below). However, as pumpage increases from the Atlantic City 800-foot sand aquifer, more water is induced to flow into it from the overlying water table aquifer. There are also other confined aquifers in the region, but pumpage from these are limited.

While the Southeastern New Jersey Study Area obtains virtually all of its potable water from wells that draw water from either the Kirkwood-Cohansey water table aquifer or the Atlantic City 800-foot sand aquifer, there are also some surface water withdrawals in the region. The Absecon Creek is only utilized by the Atlantic City Municipal Utilities Authority (ACMUA) for a portion of its daily production. In addition, there is significant agricultural use of surface water in the Mullica River and Great Egg Harbor River watersheds. Below is a detailed discussion of each of the water resources in the Southeastern New Jersey Study Area.

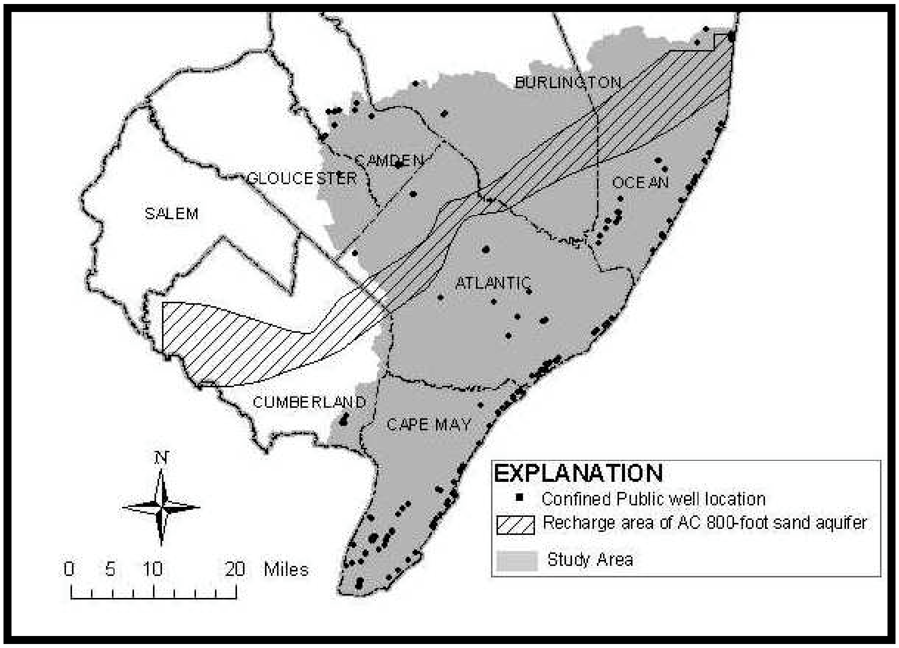

Figure 3b. Recharge Area of the Atlantic City 800-foot Sand Aquifer

3.1 KIRKWOOD-COHANSEY AQUIFER

The water table aquifer is composed primarily of sand and gravel that allows precipitation to be rapidly transmitted first downward and, then, horizontally where it discharges to nearby streams, wetlands and bays over time. The aquifer contains freshwater except along the coastal estuaries where brackish water exists. It thickens down-dip from about 150 feet near the Egg Harbor City area where it is interconnected with the Atlantic City 800-foot sand aquifer, to about 400 feet along the coast. Some regionally extensive clay beds occur, especially near the coast and along the base of the aquifer. As described above, most precipitation that recharges the water table aquifer eventually discharges into local streams and other waterbodies. Some rainfall recharges the deeper confined aquifers. On average, more than 80 percent of total streamflow in the Mullica River and Great Egg Harbor River is comprised of water that is discharged from the water table aquifer. (Johnson and Watt, 1992) and (Watt and Johnson, 1992).

Substantial depletive withdrawals from the aquifer will reduce streamflow, especially during the summer and fall months when streamflow is naturally lower because of high evapo-transpiration. As such, the water table aquifer and local surface waters should be considered essentially the same resource. Planning efforts need to consider the effects that withdrawals from the water table aquifer have on streamflow, and other natural resources that are dependent upon it.

It is estimated that the water table aquifer in the Mullica River watershed receives on average 635 MGD of recharge, while the water table aquifers in the Great Egg Harbor River, Cape May and Southern Barnegat Bay watersheds receives 311 MGD, 290 MGD and 250 MGD, respectively (Boyle, French and Canace, 1992). The vast majority of recharge occurs during the winter and spring when evapo-transpiration is low. In contrast, evapo-transpiration consumes the vast majority of recharge during the warm, growing months.

Recharge during the winter and spring months allows for streams to flow during the summer and fall months. Recharge is reduced during a prolonged drought, however, and severe streamflow reductions will occur during these periods. The severe drought of 2001-2002 exemplified this condition when record low streamflows occurred throughout southeastern New Jersey. Depletive water uses from the water table aquifer aggravate these conditions. In many cases, streamflow was less than that of the worst drought of record (the drought of 1961-1965).

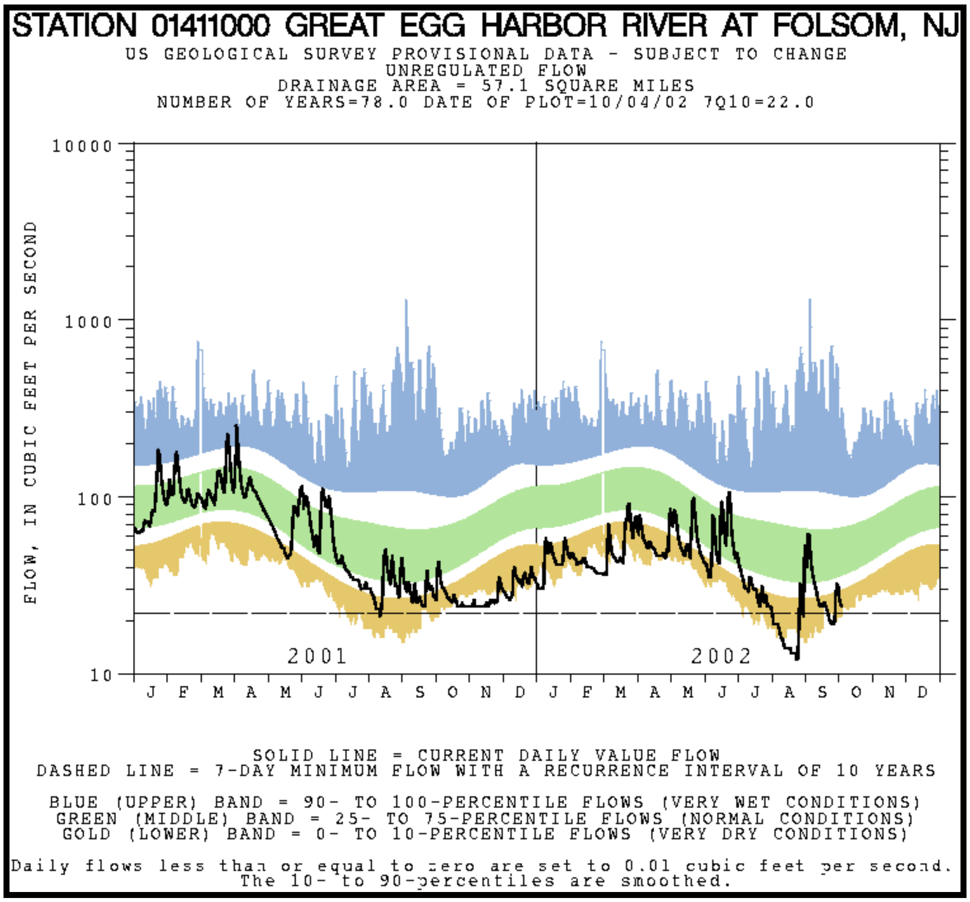

Figure 4. Effects of Drought on the Great Egg Harbor River at Folsom, NJ (USGS, 2002)

Figure 4, above, illustrates the severe effect that extreme drought can have on a waterway in the study area. As shown, the lowest flows ever recorded in the 78 years of record-keeping on the Great Egg Harbor River at Folsom occurred in August 2002. The comprehensive water supply plan recommended by this report will evaluate the effects of upstream depletive and consumptive water uses on these low flows.

3.2 ATLANTIC CITY 800-FOOT SAND AQUIFER AND OTHER CONFINED AQUIFERS

The Atlantic City 800-foot sand aquifer underlies the Kirkwood-Cohansey water table aquifer throughout the Southeastern New Jersey Study Area; a regional confining unit consisting of a thick clay deposit separates the two aquifers. In Atlantic County, the thickness of the confining unit increases in the down-dip direction from less than 100 feet in the Mays Landing area to approximately 400 feet in the vicinity of Atlantic City. The Atlantic City 800-foot sand aquifer is made up of sand, gravel and a significant amount of shell material. The aquifer ranges in thickness from less than 40 feet in the up-dip area to more than 200 feet beneath Cape May City. Due to limited availability of other local sources, this regionally expansive aquifer is the major water supply for the barrier islands of southern New Jersey. However, purveyors and others on the mainland are also increasingly using it.

The up-dip area of the Atlantic City 800-foot sand aquifer, where it is hydraulically connected with the water table aquifer, is located in southern Ocean and Burlington counties, then extends southwesterly through Atlantic and Cumberland counties. It is in this area that the aquifer receives the majority of its freshwater recharge. Prior to developing the Atlantic City 800-foot sand aquifer for water supply purposes, it has been estimated that recharge to the aquifer was about 7 MGD; of this amount, approximately 4 MGD was from the water table aquifer in the up-dip area (USGS, 1992). Offshore of Ocean County (in the Barnegat Bay area), the up-dip area extends into the Atlantic Ocean. Offshore of Cape May County the up-dip area extends into the Delaware Bay. In these areas the freshwater of the aquifer is hydraulically connected with the saltwater of these waterbodies (Voronin, Spitz and McAuley, 1996). Recharge was insubstantial because there were no withdrawals. Most potential recharge was rejected because the aquifer was saturated with water previously recharged to it.

Midway within the confining unit that separates the water table aquifer from the Atlantic City 800-foot sand aquifer is a relatively thin confined aquifer referred to as the Rio Grande water-bearing zone. It is approximately 100 feet thick in northern Cape May County and about 40 feet thick in coastal Atlantic County. The aquifer has no outcrop area; it cannot be traced more than ten miles inland from Atlantic City. Consequently, the aquifer is considered a minor water supply. It is thought to be hydraulically connected to the Atlantic City 800-foot sand aquifer. It is presently being used for water supply only in Cape May County.

The Piney Point confined aquifer is beneath the Atlantic City 800-foot sand aquifer, separated by a regionally extensive clay and silt-confining unit that averages about 100 feet in thickness. Information on this aquifer is sparse. However, it is known to contain brackish water south of Atlantic City and to be hydraulically connected to the Atlantic City 800-foot sand aquifer. Pumpage of the latter causes ground water pressure levels to decline in the Piney Point aquifer (Lacombe and Rosman, 1995). It is about 200 feet thick in southwestern Cumberland County but thins in the Atlantic County Study Area. Prior to being used as a water supply, it is estimated that the majority of water (about 5 MGD) that flowed into the Piney Point aquifer was from its up-dip location in western Burlington, Camden, Gloucester and Salem counties (USGS, 1992). The aquifer does not actually crop out at the surface; rather, it thins out to a point where it is no longer definable in the up-dip direction. The aquifer may be capable of providing moderate amounts of additional water supplies in the northern and western portions of the Southeastern New Jersey Study Area. Two barrier island municipalities in Ocean County and in Buena in Atlantic County currently use it. It also serves as a major water supply for Dover, Delaware.

3.3 SURFACE WATER SUPPLIES

The ACMUA operates two surface water reservoirs of approximately equal size, Kuehnle Pond on the South Branch of Absecon Creek and Doughty Pond on the main branch of Absecon Creek. The combined safe yield of these reservoirs is 9.3 MGD. However, only 3 MGD is used during periods when it is substantially used; no water has been withdrawn from the reservoirs in some years (NJDEP, 2000). In addition, the Mullica River is used extensively (54 MGD on average estimated) for agricultural irrigation; substantially less surface water is withdrawn for agriculture in the Great Egg Harbor River (6.0 MGD on average estimated).

3.4 GENERAL WATER QUALITY

Water quality in the Southeastern New Jersey Study Area is generally suitable for public supply with minimum treatment. However, as described throughout this report, human activities are impairing local surface and ground water resources that may be needed for future water supplies.

4.0 POPULATION/WATER DEMAND PROJECTIONS FOR THE REGION

In order to estimate water demand for the planning period, 50-year population projections were made. A 50-year planning horizon is employed to allow for a sufficient period to assess and respond to the magnitude and timing of any projected water supply deficits. Experience dictates that it can take up to two decades to plan and implement major alternative water supplies and related strategies.

4.1 POPULATION FORECASTS – 2000 to 2050

The development of long-term population projections is an art – not an exact science. Consequently, it is important to note that these population projections should be used as “tools” to assess the possible impacts of changes within the region. They are not to be used as predictions, but rather as hypothetical possibilities. The actual population and demand projections may be reached before or after the projected time. This will be especially true as the state, counties and municipalities debate how future Intelligent Growth development will occur. However, the impacts of increased water demand are more predictable and are the real focus of this report. NJDEP expects to update these projections, compare them to the analysis of this report, and “fine tune” the actions necessary for the Southeastern New Jersey Study Area in cooperation with local interests as part of the more comprehensive assessment that this report recommends (see Section 9.2). Beyond that assessment, the NJDEP will further refine the projections as future data is collected. Therefore, upward or downward changes in short-term trends can be addressed through future planning processes.

This report primarily used two sources of information to estimate the planning period population of the Southeastern New Jersey Study Area, and that for Egg Harbor, Galloway and Hamilton townships, in particular. First, the Year 2000 Census, as published by the New Jersey State Data Center within the New Jersey Department of Labor, was used as the baseline for the projections and to identify previous growth trends among study area counties (N.J. Department of Labor, 2001). Specifically, the growth trends of the counties wholly or partially in the Southeastern New Jersey Study Area were calculated for the period 1990 to 2000. Second, the New Jersey Department of Labor's 1998–2015 county population projections were employed to estimate the future potential growth trends for these counties for the period 2000 to 2010. The New Jersey Department of Labor made no municipal projections, nor were watershed projections made by this agency.

The first step in developing long-term projections for the Southeastern New Jersey Study Area was to identify the actual 1990 to 2000 population growth rates (in percentages) in the counties that are wholly or partially within the study area based on previous U.S. Census data, and the 2000-2010 projected growth rates for these counties based on the New Jersey Department of Labor's estimates. These two rates were then averaged to project future growth rates in the counties after Year 2010 in ten-year increments.

TABLE 1

POPULATION FORECASTS FOR THE COUNTIES WHOLLY OR PARTIALLY IN THE SOUTHEASTERN NEW JERSEY STUDY AREA

	1990	2000	1990-2000 RATE	2010	2000-2010 RATE	1990-2010 RATE/DECADE	2020	2030	2040	2050
NEW JERSEY	7,730,188	8,414,350	8.9%	9,062,800	7.7%	8.3%	9,815,012	-	-	-
COUNTY										
ATLANTIC	224,327	252,552	12.6%	274,400	8.7%	10.7%	303,761	336,263	372,244	412,074
BURLINGTON	395,066	423,394	7.2%	464,700	9.8%	8.5%	504,200	547,057	593,557	644,009
CAMDEN	502,824	508,932	1.2%	530,900	4.3%	2.8%	545,765	561,047	576,756	592,905
CAPE MAY	95,089	102,326	7.6%	106,600	4.2%	5.9%	112,889	119,550	126,603	134,073
CUMBERLAND	138,053	146,438	6.1%	148,900	1.7%	3.9 %	154,707	160,741	167,010	173,523
GLOUCESTER	230,082	254,673	10.7%	278,200	9.2%	10.0%	306,020	336,622	370,284	407,313
OCEAN	433,203	510,916	17.9%	575,700	12.7%	15.3%	663,782	765,341	882,438	1,017,451

As Table 1 shows, Ocean, Atlantic, Gloucester and Burlington counties are projected to grow at a faster rate than the State as a whole, with Ocean County expected to grow at almost twice the State rate. Cape May, Cumberland and Camden counties are projected to grow less than the State average.

The second step to projecting the population of the Southeastern New Jersey Study Area required the identification of municipalities (and counties) that are within the watersheds comprising the Southeastern New Jersey Study Area, and their U.S. Census Year 2000 population. The municipality/watershed delineation was taken from work done for the 1996 Plan that placed an entire municipality in a particular watershed if 51 percent or more of it fell in the watershed. (This approach tends to balance itself out in the whole picture.) Note that a county can be in more than one watershed. Then, since the New Jersey Department of Labor did not project population growth rates to Year 2050 for the individual municipalities within the counties or watersheds, the approach taken for this report consisted of: 1) totaling Year 2000 populations of the municipalities in each of the counties/watersheds comprising the Southeastern New Jersey Study Area, and 2) applying the county 1990 to 2010 rates of growth to the applicable Year 2000 watershed population out to the end of the planning period. Appendix A contains the U.S. Census Year 2000 populations of the municipalities comprising the watersheds of the study area.

Table 2 presents Year 2000 populations and projections out to Year 2050 for the Southeastern New Jersey Study Area by watershed. The Year 2000 study area population is approximately 557,424 persons, with almost half residing in the Mullica River watershed, particularly in the Atlantic County portion of the watershed. Each of the other three watersheds in the Southeastern New Jersey Study Area, Cape May, Great Egg Harbor, and Southern Barnegat, has approximately 100,000 residents as of Year 2000.

Based on the above approach, the entire Southeastern New Jersey Study Area is projected to grow to 895,535 by Year 2050 - an increase of about 61 percent. As a whole, the watershed is projected to grow approximately 9.7 percent per decade. While the Atlantic County portion of the Mullica River watershed continues to dominate the largest percentage of overall increases in projected growth, the Southern Barnegat watershed is expected to have the next largest population in the Southeastern New Jersey Study Area.

TABLE 2

WATERSHED POPULATION PROJECTIONS FOR THE SOUTHEASTERN NEW JERSEY STUDY AREA

Watershed	County (or Portion of County) in Study Area	2000	1990-2010 RATE/ DECADE [4]	2010	2020	2030	2040	2050
	COUNTY							
Mullica	Atlantic County	214,462	10.7%	237,409	262,812	290,933	322,063	356,523
	Burlington County	16,933	8.5%	18,372	19,934	21,628	23,467	25,461
	Camden County	12,014	2.8%	12,350	12,696	13,052	13,417	13,793
	Sub-Total	243,409	10.2%	268,131	295,442	325,613	358,947	395,777
Cape May	Cape May County	102,326	5.9%	108,363	114,757	121,527	128,697	136,291
	Cumberland County	6,928	3.9%	7,198	7,479	7,770	8,073	8,388
	Sub-Total	109,254	5.8%	115,561	122,236	129,297	136,770	144,679
Great Egg	Atlantic County	38,090	10.7%	42,166	46,678	51,672	57,201	63,322
	Gloucester County	28,967	10.0%	31,864	35,050	38,555	42,411	46,652
	Camden County	39,901	2.8%	41,018	42,167	43,347	44,561	45,809
	Sub-Total	106,958	7.6%	115,048	123,895	133,574	144,173	155,783
So Barnegat	Ocean County	97,803	15.3%	112,767	130,020	149,913	172,850	199,296
	Sub-Total	97,803	15.3%	112,767	130,020	149,913	172,850	199,296
	Region Total	557,424	9.7%	611,507	671,593	738,397	812,740	895,535

In addressing uncertainties regarding the above population projections, experience has shown that the longer the planning period and the smaller the area for which the

[4] Rounding off to the nearest decimal will result in small, but relatively insignificant, inaccuracies.

assessment is made, the greater the potential for either an over- or under-estimation. Further, the state, counties and municipalities are all examining how they wish to grow in the decades to come. These efforts will most certainly result in substantial modifications to the above projections, especially in specific areas within the Southeastern New Jersey Study Area. Lastly, some of the areas within the watershed are nearly at build-out conditions; even with redevelopment efforts, the overall populations may not significantly change. Refined population projections will be made during the course of the proposed regional water supply plan to address these uncertainties (see Section 9.2, Findings and Recommendations).

From a water supply planning perspective, the most important activity regarding population projections is to monitor growth and its consequent changes in demand against specific water withdrawal thresholds. (See Section 5.0 in this report for specific withdrawal effects.) As demand grows, previously selected alternative water supplies and demand reduction options will be implemented prior to a specific water supply reaching deficit conditions.

Individual population projections for Egg Harbor, Galloway and Hamilton townships are summarized in Table 3. Like the county and watershed projections, these forecasts assume that the three municipalities will grow at the same rate as the average of the 1990 to 2000 actual growth rate and that rate projected for the county as a whole between 2000 and 2010. Of course, these projections are subject to the same uncertainties as discussed above. It needs to be emphasized, however, that these towns are planned growth centers, and growth is expected to be significantly greater than surrounding areas.

TABLE 3

POPULATION PROJECTIONS FOR EGG HARBOR, GALLOWAY AND HAMILTON TOWNSHIPS

LOCATION	1990	2000	1990-2000 RATE	2010	2000-2010 RATE	1990-2010 RATE/ DECADE	2020	2030	2040	2050
NEW JERSEY	7,730,188	8,414,350	8.9%	9,062,800	7.7%	8.3%	9,780,900	-	-	-
ATLANTIC CO.	224,327	252,552	12.6%	274,400	8.7%	10.7%	303,761	336,263	372,244	412,074
Egg Harbor	24,544	30,726	25.2%	33,399	8.7%	17.0%	39,078	45,720	53,492	62,586
Galloway	23,330	31,209	33.8%	33,924	8.7%	21.3%	41,150	49,915	60,547	73,443
Hamilton	16,012	20,499	28.0%	22,284	8.7%	18.4%	26,384	31,239	36,987	43,793
Total		82,434								179,822

As Table 3 illustrates, growth is projected to be substantial in the three municipalities during the planning period. Each of the municipality's populations are forecast to more than double over the next five decades, based on the above growth rates. If these projections are realized, the populations of the three towns will represent almost half of the population of the entire county. They currently represent about a third of the county's population.

4.2 WATER DEMAND FORECASTS – 2000 to 2050

Water demand projections in the Southeastern New Jersey Study Area employed, for the most part, the most recent water withdrawal information that was comprehensively collected (average demand between 1990 to 1996) to serve as the baseline. An abbreviated assessment concluded that there was an insignificant difference between the averaged 1990 to 1996 data (when withdrawal data was comprehensively disaggregated) and 1999 (when withdrawal data was last inventoried but not yet disaggregated for detailed analyses). Table 4 summarizes current (1990 to 1996) demand from each of the major sources (surface water, unconfined and confined aquifer) in the entire Southeastern New Jersey Study Area. While domestic sources are identified as an individual source, it is assumed that the majority of private wells obtain their water from the unconfined aquifers of the watersheds making up the Southeastern New Jersey Study Area. When demand from the various sources are estimated in this report, domestic demand will thus be assumed to be from the unconfined aquifers in the study area.

TABLE 4
CURRENT (1990-1996) WATER DEMAND IN THE
SOUTHEASTERN NEW JERSEY STUDY AREA
BY INDIVIDUAL SOURCE
MILLION GALLONS PER DAY (AVERAGE)

SOURCE	1990-1996
Surface	61.38
Unconfined	67.58
Confined	42.60
Unknown	0.51
Domestic	22.55
TOTAL	194.62

As Table 4 shows, the majority of water diverted from the Southeastern New Jersey Study Area is from unconfined aquifers (90.13 MGD when domestic withdrawals are included), followed by surface water withdrawals (61.38 MGD) and confined withdrawals (42.60 MGD). Figure 5 below provides the general location of all wells that have water allocations and public supply surface water withdrawals in the Southeastern New Jersey Study Area. Figures 6 provides the general locations of all the public wells in the unconfined aquifers that have water allocations in the Study Area. Figure 7.a provides the general locations of all the public potable supply wells in the confined aquifers of the region, while Figure 7.b shows the wells in the Atlantic City 800-foot sand aquifer in the Study Area.

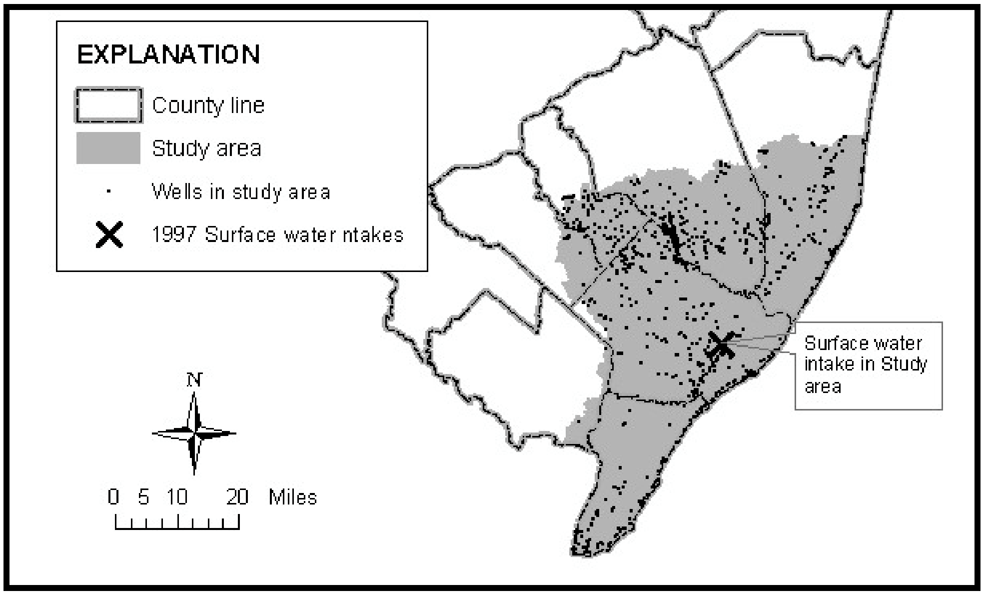

Figure 5. Potable Supply Surface Intakes and Wells in All Aquifers in the Southeastern New Jersey Study Area

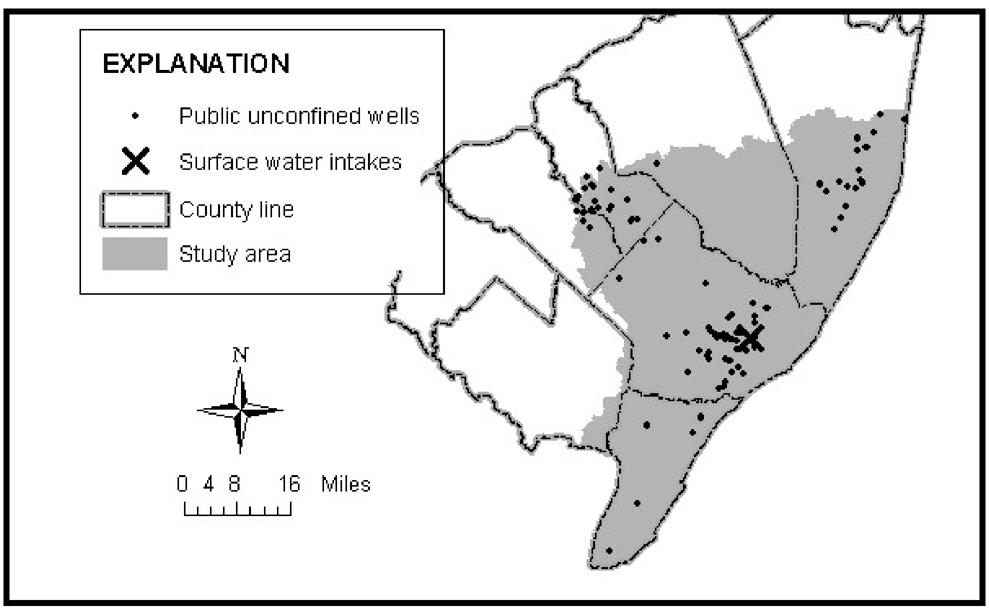

Figure 6. Public Wells in the Unconfined Aquifers and Potable Supply Surface Water Intakes in the Southeastern New Jersey Study Area

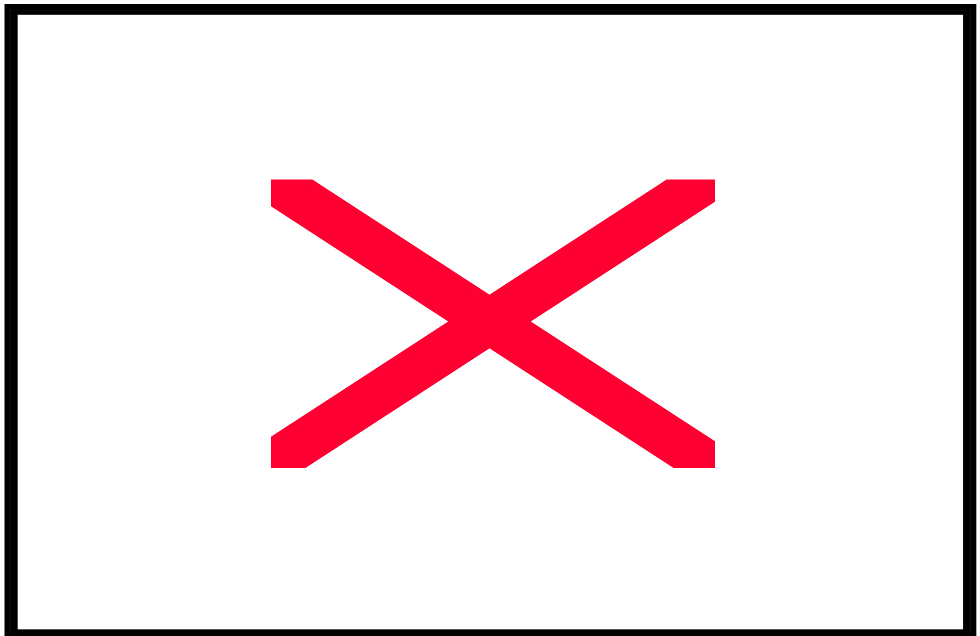

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Figure 7a. Public Wells in the Confined Aquifer in the Southeastern New Jersey Study Area

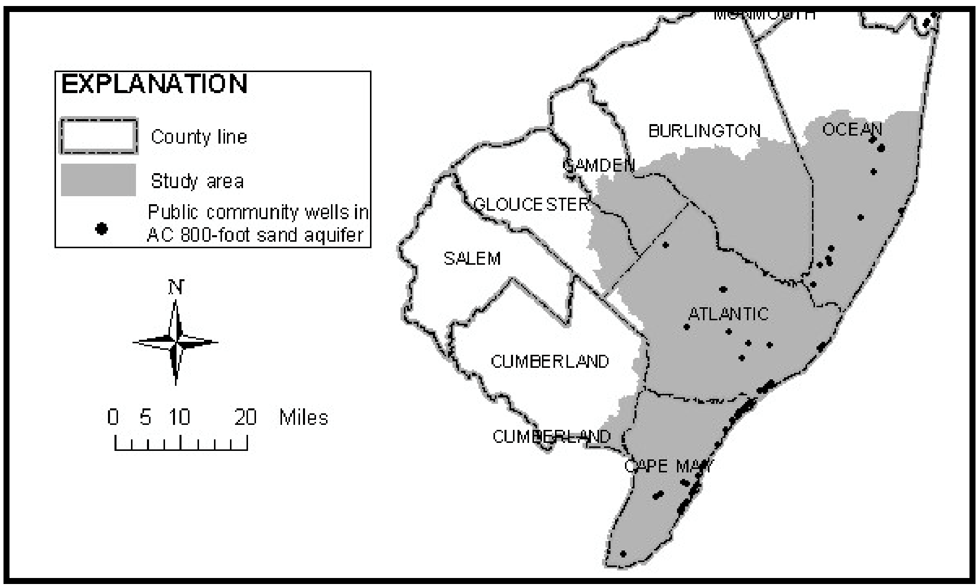

Figure 7b. Public Wells in the Atlantic City 800-Sand Aquifer in the Southeastern New Jersey Study Area

Table 5 shows the amount of water from the various sources that Egg Harbor, Galloway and Hamilton townships used in 1999. Most of the unconfined aquifer withdrawals in these municipalities are in the Great Egg Harbor River watershed.

TABLE 5
CURRENT (1999) WATER DEMAND IN
EGG HARBOR, GALLOWAY AND HAMILTON TOWNSHIPS
BY INDIVIDUAL SOURCE
MILLION GALLONS PER DAY (AVERAGE)

TOWNSHIP/WATERSHED	SOURCE	1999
EGG HARBOR TOWNSHIP		
GREAT EGG HARBOR	Surface	-
	Unconfined	15.2

	Confined	0.5
	Unknown	-
	Domestic	2.4
	SUB-TOTAL	18.1
GALLOWAY TOWNSHIP		
MULLICA/GREAT EGG HARBOR	Surface	-
	Unconfined	2.0
	Confined	0.7
	Unknown	-
	Domestic	2.5
	SUB-TOTAL	5.2
HAMILTON TOWNSHIP		
GREAT EGG HARBOR	Surface	-
	Unconfined	0.7
	Confined	1.0
	Unknown	-
	Domestic	0.7
	SUB-TOTAL	2.4
	TOTAL	25.7

As illustrated in Table 5, the three municipalities currently withdraw about 26 MGD, or approximately 13 percent of all water withdrawn in the Southeastern New Jersey Study Area. As substantiated below, the three towns withdraw about half of all the water used in the Great Egg Harbor watershed. Assuming that the majority of domestic wells are in the Kirkwood-Cohansey aquifer, more than 90 percent of the water withdrawn in the three towns is from this water table aquifer. Approximately 70 percent of all water withdrawn by the three towns is diverted by Egg Harbor Township.

Egg Harbor Township - Approximately 15.7 MGD are withdrawn on average in Egg Harbor Township from those holding water allocation permits; the vast majority is from the Cohansey aquifer. Approximately 13.1 MGD are withdrawn during the winter and about 18.2 MGD during the summer months, or about a 40 percent increase during the latter months. During peak months, as much as 22 MGD are withdrawn. Some of this increase is due to the summer tourist trade, but is assumed that the majority of the increase is the result of irrigation. The ACMUA exports most of the water withdrawn from Egg Harbor Township to the barrier islands (8.2 MGD on average). The NJ American Water Company provides most of the water to those within its franchise area in the township. Withdrawals by this purveyor average about 4.8 MGD.[5] During the summer months, approximately 5.7 MGD are withdrawn; peaks as high as 7.7 MGD occur during the dryer summer months.

The 1996 Plan made estimates of the population in each municipality served by domestic wells (NJDEP, 1996). It was estimated that 75.5 percent of the 1990 population of Egg Harbor Township was served by private wells. Assuming that the same percentage of the current (2000) population is served by private wells, about 23,198 people are estimated to be served by private wells. If each person uses 75 gallons per day for indoor use, about 1.7 MGD is withdrawn on average. If it is further assumed that homeowners irrigate at the same rate as those on public water (about a 40 percent increase during the warmer months), and that these homeowners use about twice the amount of water because they

[5] It is assumed that a large portion of that withdrawal is exported from Egg Harbor Township.

are likely to be on larger lots than those served by public water, it is estimated that this user group withdraws about 2.4 MGD on average. Again, these assumptions will need to be verified in the more comprehensive water supply plan.

Galloway Township - It is estimated that there currently are about 2.7 MGD withdrawn on average in Galloway Township by those entities possessing water allocation permits. Most of the withdrawals are by the NJ American Water Company; the Richard Stockton College withdraws a smaller amount. Approximately 2.0 MGD are withdrawn from the unconfined Cohansey aquifer and 0.7 MGD withdrawn from the deeper confined aquifer. Winter withdrawals average about 2.3 MGD, while summer withdrawals climb about 40 percent to 3.2 MGD. During peak periods, withdrawals can be as high as 4.1 MGD. The same methodology for estimating domestic wells, that was used above, predicted that there were about 23,563 people using private wells in the township in 2000. It was consequently estimated that this user group withdraws 2.5 MGD on average.

Hamilton Township - Approximately 1.7 MGD are withdrawn on average from those holding water allocation permits in Hamilton Township. The winter average is 1.3 MGD and the summer average is 2.1 MGD. Peak demand can reach 2.8 MGD. On average, about 1.0 MGD are withdrawn from the confined aquifer and 0.7 MGD from the unconfined aquifer. The Hamilton Township Municipal Utilities Authority withdraws the majority of water. It is estimated there are 9,491 people in the township using private wells. This is estimated to represent an average withdrawal of 0.7 MGD.

Surface water is also withdrawn periodically from the ACMUA's two reservoirs in Egg Harbor, Galloway and Absecon townships. However, between 1990 and 1996, these withdrawals ranged from zero to less than 3.0 MGD (on average). Due to the wide fluctuation of these withdrawals and the fact that the water in these reservoirs is in three municipalities, it was decided that a future assessment of this supply should be conducted in the more comprehensive water supply plan.

The averaged watershed growth rates estimated for the population projections above were used to project water demand out to Year 2050 from the various sources within the Southeastern New Jersey Study Area. Table 5 showed a summary of current (1990 to 1996) water demand and projections of water demand in ten-year increments out to Year 2050. It is estimated that demand in the entire Southeastern New Jersey Study Area will increase about 63 percent during the planning period. The projected rate of demand increases is largely inflated by the expected increase in the Southern Barnegat Bay watershed, which is projected to increase more than 100 percent during the planning period.

It should be noted that water demand does not necessarily increase at the same incremental rate as the population on an annual basis. Annual water demand is often a function of the amount of rainfall that a region experiences - the less rainfall during the spring and summer the higher the demand. The opposite typically occurs during a wetter than normal spring and summer. However, the rate that demand increases typically parallels the rate that the population increases over the longer term, assuming no major changes in activities and climate patterns that may significantly alter water use. A more comprehensive examination of water demand projections will be made as part of the water supply plan recommended by this report.

TABLE 6 WATER DEMAND PROJECTIONS IN THE SOUTHEASTERN NEW JERSEY STUDY AREA (MILLION GALLONS PER DAY – AVERAGE)							
WATER-SHED	**1996-2000**	**1990-2010 WATERSHED GROWTH RATE PER DECADE**	**2010**	**2020**	**2030**	**2040**	**2050**
Mullica	95.3	10.2%	105.0	116.4	128.2	141.3	155.7
Cape May	24.1	5.8%	25.5	27.0	28.5	30.2	31.9
Great Egg	55.84	7.6%	60.1	64.7	69.6	74.9	80.6
So Barnegat	19.38	15.3%	22.3	25.8	29.7	34.3	39.5
TOTAL	194.62	9.7%	212.9	233.9	256.0	280.7	307.7

Table 7 below was developed to forecast water demand by individual source out to Year 2050. However, water conservation measures that might be implemented in the future could reduce this demand to some degree. On the other hand, withdrawals from the Atlantic City 800-foot sand aquifer may increase more than projected. The Pinelands Commission currently discourages withdrawals from the water table aquifer within its jurisdiction due to the potential ecological impacts that may accompany these withdrawals. Further, future water users may be inclined to drill wells into the deeper aquifer due to water quality concerns related to the water table aquifer.

TABLE 7 WATER DEMAND PROJECTIONS FOR THE INDIVIDUAL SUPPLY SOURCES IN THE SOUTHEASTERN NEW JERSEY STUDY AREA (MILLION GALLONS PER DAY – AVERAGE)							
WATERSHED/SOURCE	**1996-2000**	**1990-2010 WATERSHED GROWTH RATE PER DECADE[6]**	**2010**	**2020**	**2030**	**2040**	**2050**
MULLICA							
Surface	53.6	10.2%	59.1	65.1	71.7	79.0	87.1
Unconfined	30.0	10.2%	33.1	36.4	40.1	44.2	48.8
Confined	5.1	10.2%	5.6	6.2	6.8	7.5	8.3
Domestic	6.3	10.2%	6.9	7.7	8.4	9.3	10.2
Sub-Total	95.3	10.2%	105.0	115.7	127.5	140.5	154.9
CAPE MAY							
Surface	2.3	5.8%	2.4	2.5	2.7	2.8	3.0
Unconfined	4.4	5.8%	4.6	4.9	5.2	5.5	5.8
Confined	13.8	5.8%	14.6	15.4	16.3	17.3	18.3
Unknown	0.01	5.8%	0.01	0.01	0.01	0.01	0.01
Domestic	3.7	5.8%	3.9	4.1	4.3	4.6	4.8
Sub-Total	24.1	5.8%	25.5	27.0	28.5	30.2	32.1
GREAT EGG							
Surface	5.5	7.6%	5.9	6.4	6.9	7.4	7.9
Unconfined	31.5	7.6%	33.9	36.5	39.2	42.2	45.4
Confined	12.3	7.6%	13.2	14.2	15.3	16.5	17.7
Unknown	0.04	7.6%	0.04	0.05	0.05	0.05	0.06
Domestic	6.5	7.6%	7.0	7.5	8.1	8.7	9.4
Sub-Total	55.84	7.6%	60.1	64.7	69.6	74.9	80.6
SOUTHERN BARNEGAT							
Surface	0.18	15.3%	0.2	0.2	0.3	0.3	0.4
Unconfined	1.7	15.3%	2.0	2.3	2.6	3.0	3.5
Confined	11.4	15.3%	13.1	15.2	17.5	20.1	23.2
Unknown	-	15.3%	-	-	-	-	-
Domestic	6.1	15.3%	7.0	8.1	9.4	10.8	12.4
Sub-Total	19.38	15.3%	22.3	25.8	29.7	34.3	39.5

[6] Narrowing to the nearest hundred thousand gallons causes slight discrepancies in the amounts over time.

TOTAL	194.62	9.5	212.9	233.2	255.3	279.9	307.1

Based on the above table, water demand projections for the individual sources within the Southeastern New Jersey Study Area were estimated and are presented in Table 8. Water withdrawals vary substantially among the various use categories in the watersheds comprising the Southeastern New Jersey Study Area.

TABLE 8
PROJECTED (2000-2050) WATER DEMAND IN THE SOUTHEASTERN NEW JERSEY STUDY AREA BY INDIVIDUAL SOURCE
MILLION GALLONS PER DAY (AVERAGE)

SOURCE	1990-1996	2050[7]
Surface	61.38	98.40
Unconfined	67.58	103.50
Confined	42.60	67.50
Unknown	0.51	0.87
Domestic	22.55	36.83
TOTAL	194.38	307.10

Table 9 provides a summary of these uses and the amounts that these uses withdraw. The quantities represent the average amounts withdrawn from 1990 to 1996. This information will be useful when evaluating opportunities for conserving water during the development of the water supply plan for the region.

As Table 9 shows, the use category that withdraws the largest amount of water in the Southeastern New Jersey Study Area is agriculture; the vast majority is from surface and ground water sources in the Mullica River watershed. The potable supply category withdraws slightly less than the agriculture sector; most of this withdrawal is from ground water in the Great Egg Harbor watershed. Significant potable withdrawals are also occurring in the Southern Barnegat Bay, Cape May and Mullica River watersheds. Other use categories in the region withdraw substantially less than those withdrawn for the agriculture and potable supply use categories. Mining withdrawals are somewhat significant in the Great Egg Harbor and Mullica River watersheds.

TABLE 9
1990-1996 WATER DEMAND BY USE CATEGORY
SOUTHEASTERN NEW JERSEY STUDY AREA
MILLION GALLONS PER DAY (AVERAGE)

WATER USE	MULLICA			CAPE MAY			GREAT EGG			SO. BARNEGAT			T
	SW	GW	T	SW	GW	T	SW	GW	T	SW	GW	T	

[7] Narrowing to the nearest hundred thousand gallons causes slight discrepancies in the amounts over time.

POWER GENERATION	0	0	0	0	0.4	0.4	0	0.4	0.4	0	0	0	0.8
MINING	0	4.7	4.7	2.2	4.0	6.2	3.9	3.9	7.8	0	0	0	18.7
INDUSTRIAL	0	0.5	0.5	0	0.2	0.2	0	1.9	1.9	0	0	0	2.6
COMMERCIAL/ RECREATION	0	0	0	0	0	0	0	0.6	0.6	0	0	0	0.6
POTABLE SUPPLY	0	11.0	11.0	0	16.1	16.1	1.1	39.2	40.3	0	16.4	16.4	83.8
IRRIGATION	0	0.3	0.3	0.1	0.3	0.4	0.2	0.4	0.6	0	0	0	1.3
AGRICULTURE	53.9	25.1	79.0	0	0.8	0.8	0.4	4.2	4.6	0	0	0	84.4
TOTAL	53.9	41.6	95.5	2.3	21.9	24.1	5.6	50.6	56.2	0	16.4	16.4	192.2

SW = Surface Water GW = Ground Water T = Total

Withdrawals less than 100,000 not included

The various water uses and their consequent demands are projected to the end of Year 2050 in Table 10 below. These projections also employed the watershed growth rates described above; they assume that the water uses will grow proportionate to the population forecasts made for the watersheds.

These projections assume that the rate of demand increases for specific use categories will approximate the rate of population increases for the watersheds in the Southeastern New Jersey Study Area. However, the rate of demand for certain activities may not strictly follow the rate of population growth. For example, while the population of New Jersey grew by 8.9 percent during the 1990 to 2000 period, the rate of demand for power generation declined during this same period. On the other hand, increases in agricultural demand during this period were approximately equal to increases in population, despite the loss of land to development. This is thought to occur due to increases in irrigation by the agricultural industry. Whether this trend will continue in the decades to come is debatable. Issues such as these will be more closely addressed during the development of the water supply plan for the region.

Based on the projections in Table 10, significant demand is anticipated from the agricultural industry and for potable supply needs. This is especially true in the Mullica River and Great Egg Harbor River watersheds, respectively. If the mining industry grows at the same rate as the populations in the watersheds, withdrawals will be substantial in these two watersheds.

TABLE 10

2000-2050 WATER DEMAND BY USE CATEGORY

SOUTHEASTERN NEW JERSEY STUDY AREA

MILLION GALLONS PER DAY (AVERAGE)

WATER USE	MULLICA			CAPE MAY			GREAT EGG			SO. BARNEGAT			T
	SW	GW	T	SW	GW	T	SW	GW	T	SW	GW	T	
POWER GENERATION	0	0	0	0	0.4	0.4	0	0.4	0.4	0	0	0	0.8

POWER GENERATION	0	0	0	0	0.5	0.5	0	0.6	0.6	0	0	0	1.1
MINING	0	4.7	4.7	2.2	4.0	6.2	3.9	3.9	7.8	0	0	0	18.7
MINING	0	7.7	7.7	2.9	5.3	8.2	5.7	5.7	11.4	0	0	0	27.3
INDUSTRIAL	0	0.5	0.5	0	0.2	0.2	0	1.9	1.9	0	0	0	2.6
INDUSTRIAL	0	0.8	0.8	0	0.3	0.3	0	2.8	2.8	0	0	0	3.9
COMMERCIAL/ RECREATION	0	0	0	0	0	0	0	0.6	0.6	0	0	0	0.6
COMMERCIAL/ RECREATION	0	0	0	0	0	0	0	0.9	0.9	0	0	0	0.9
POTABLE SUPPLY	0	11.0	11.0	0	16.1	16.1	1.1	39.2	40.3	0	16.4	16.4	83.8
POTABLE SUPPLY	0	17.9	17.9	0	21.4	21.4	1.6	56.8	58.4	0	35.3	35.3	133.0
IRRIGATION	0	0.3	0.3	0	0.3	0.3	0.2	0.4	0.6	0	0	0	1.2
IRRIGATION	0	0.5	0.5	0	0.4	0.4	0.3	0.6	0.9	0	0	0	1.8
AGRICULTURE	53.9	25.1	79.0	0	0.8	0.8	0.4	4.2	4.6	0	0	0	84.4
AGRICULTURE	87.9	40.9	128.9	0	1.1	1.1	0.6	6.1	6.7	0	0	0	136.7
TOTAL – 2000	53.9	41.6	95.5	2.2	21.8	24.0	5.6	50.6	56.2	0	16.4	16.4	192.1
TOTAL - 2050	87.9	67.8	155.7	2.9	29.0	31.9	8.2	73.5	81.7	0	35.3	35.3	304.6

SW = Surface Water GW = Ground Water T = Total

Year 2000 Year 2050 Withdrawals less than 100,000 not included

The seasonal and depletive/consumptive nature of water use from surface water and unconfined aquifers is required to properly assess the impacts to streamflow and wetlands, especially that used during the summer months. As described earlier, flows in rivers and streams are naturally lower during the growing months as a consequence of high evapo-transpiration that occurs during these periods. Excessive withdrawals from surface water and unconfined aquifers can thus lower these flows even further and degrade water quality and/or impair indigenous aquatic resources. Excessive depletive and consumptive withdrawals can also affect the yield of downstream surface and ground water supplies.

The yields of these supplies are based on historic streamflow patterns. Substantial withdrawals upstream of reservoirs reduce the yield of these supplies. The same is true of ground water withdrawals that are regulated by minimum stream passing flows. Excessive groundwater withdrawals upstream of any given well will cause the minimum flow to occur prematurely and require that well to cease pumpage earlier than it normally would.

Tables 11, below, estimates the depletive/consumptive nature of the various generic user groups withdrawing surface and ground water supplies from the watersheds comprising the Southeastern New Jersey Study Area. These rates have, for the most part, been adopted from a literature review currently being conducted by NJDEP. These rates do not apply to confined aquifer withdrawals. The effects of these withdrawals will be assessed in Section 5.0 in this report.

TABLE 11

RATE OF SUMMER MONTH DEPLETION/CONSUMPTION FROM THE VARIOUS USER GROUPS WITHDRAWING FROM SURFACE WATER AND UNCONFINED AQUIFERS IN THE SOUTHEASTERN NEW JERSEY STUDY AREA

POWER GENERATION (DISCHARGE TO BRACKISH WATER)	100%
MINING	12%
INDUSTRIAL (ON-SITE DISCHARGE)	10% OF INDOOR USE AND 90% OF OUTDOOR USE
INDUSTRIAL (REGIONAL DISCHARGE)	100% OF INDOOR USE AND 90% OF OUTDOOR USE
COMMERCIAL/RECREATION	0%
POTABLE SUPPLY (ON-SITE DISCHARGE)	90% OF OUTDOOR USE
POTABLE SUPPLY (REGIONAL DISCHARGE)	100% OF INDOOR USE AND 90% OF OUTDOOR USE
IRRIGATION	90%
AGRICULTURE	90%

Demand from surface water and unconfined aquifer supplies for the various use categories in the watersheds of the region was, then, estimated and averaged for the six warmest months (May through October). Demand was also estimated for the six colder months for municipalities and industries to extrapolate depletive loss through regional sewer systems. Then, the above estimated depletive/consumptive loss rates were applied to all withdrawals in the Southeastern New Jersey Study Area in Table 12. Later in the report (Section 5), the potential impacts to low streamflow was examined.

The information contained in Table 12 is among the most important of the report. It shows where excessive depletive and consumptive uses from surface water and unconfined aquifers could lead to potential water resource problems, such as impairment of water quality and aquatic life. Current depletive and consumptive uses from surface water and unconfined aquifers during peak withdrawal periods are estimated to be 175.4 MGD and are projected to grow to 278.4 MGD by Year 2050. Nearly all of the water withdrawn from these sources in the Southeastern New Jersey Study Area is depletive or consumptive. This is due to the sheer magnitude of agricultural withdrawals, regional sewering and the intensity of residential and commercial irrigation in the study area. Agricultural and potable supply in the Mullica River, and potable supply in the Great Egg Harbor River and Southern Barnegat Bay watersheds, are particularly noteworthy.

TABLE 12

PROJECTED (2000-2050) DEPLETIVE/CONSUMPTIVE LOSSES BY USE CATEGORY WITHDRAWING FROM SURFACE WATER AND UNCONFINED AQUIFERS IN THE SOUTHEASTERN NEW JERSEY STUDY AREA

MILLION GALLONS PER DAY (AVERAGE)

WATER USE	MULLICA			CAPE MAY			GREAT EGG			SO. BARNEGAT			T
	SW	GW	T	SW	GW	T	SW	GW	T	SW	GW	T	
POWER GENERATION	0	0	0	0	0	0	0	0.4	0.4	0	0	0	0.4
POWER GENERATION	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0.5
MINING	0	0.9	0.9	0.3	0.5	0.8	0.5	0.5	1.0	0	0	0	2.7
MINING	0	1.5	1.5	0.4	0.6	1.0	0.7	0.7	1.4	0	0	0	3.9
INDUSTRIAL	0	0.1	0.1	0	0	0	0	0.2	0.2	0	0	0	0.3
INDUSTRIAL	0	0.2	0.2	0	0	0	0	0.3	0.3	0	0	0	0.5
COMMERCIAL/ RECREATION	0	0	0	0	0	0	0	0	0	0	0	0	0
COMMERCIAL/ RECREATION	0	0	0	0	0	0	0	0	0	0	0	0	0
POTABLE SUPPLY	0	8.1	8.1	0	3.5	3.5	1.4	37.2	38.6	0	6.4	6.4	56.6
POTABLE SUPPLY	0	13.2	13.2	0	4.7	4.7	2.0	53.9	56.0	0	13.8	13.8	87.7
IRRIGATION	0	0.6	0.6	0	0.3	0.3	0	0.4	0.4	0	0	0	1.3
IRRIGATION	0	0.5	0.5	0	0.4	0.4	0.4	0.7	1.1	0	0	0	2.0
AGRICULTURE	71.2	33.4	104.6	0	0.7	0.7	0.7	8.1	8.8	0	0	0	114.1
AGRICULTURE	116.1	54.4	170.5	0	0.9	0.9	0.8	11.7	12.5	0	0	0	183.9
TOTAL – 2000	71.2	43.1	114.3	0.3	5.0	5.0	2.6	46.8	49.4	0	6.4	6.4	175.4
TOTAL - 2050	116.1	69.8	185.9	0.4	6.6	7.0	3.9	67.8	71.7	0	13.8	13.8	278.4

SW = Surface Water GW = Ground Water T = Total

Year 2000 (white) Year 2050 (shaded) Withdrawals less than 100,000 not included

The majority of water withdrawn in Egg Harbor, Galloway and Hamilton townships is used for potable supply in a depletive and consumptive manner. Most of the homes and businesses in the three towns that are served by public water are also served by public sewer. The ACMUA receives the wastewater, treats it and discharges it into the ocean. Also, significant amounts of water are exported from Egg Harbor Township (where it then is converted to wastewater and discharged to the ocean). Last, while a significant portion of the population of the three towns are served by septic systems which recharge much of the water that is obtained by private wells, a substantial amount is consumptively lost through summer irrigation (assuming that this segment of the population irrigates in a similar fashion as its public water counterparts). Many of these assumptions will be more comprehensively investigated in the proposed water supply plan.

TABLE 13
CURRENT (1999) WATER DEMAND IN THE
EGG HARBOR, GALLOWAY AND HAMILTON TOWNSHIPS[8]
BY INDIVIDUAL SOURCE
MILLION GALLONS PER DAY (AVERAGE)

TOWNSHIP/WATERSHED	SOURCE	1999 DEMAND	1990-2010 RATE/ DECADE	2010 DEMAND	2020 DEMAND	2030 DEMAND	2040 DEMAND	2050 DEMAND
EGG HARBOR TOWNSHIP			17%					
GREAT EGG HARBOR	Surface	-		-	-	-	-	-
	Unconfined	15.2		17.8	20.8	24.3	28.5	33.3
	Confined	0.5		0.6	0.7	0.8	0.9	1.1
	Unknown	-		-	-	-	-	-
	Domestic	2.4		2.8	3.3	3.8	4.5	5.3
	SUB-TOTAL	18.1		21.2	24.8	30.0	33.9	39.7
GALLOWAY TOWNSHIP			21.3%					
MULLICA/GREAT EGG HRBR.	Surface	-		-	-	-	-	-
	Unconfined	2.0		2.4	2.9	3.6	4.3	5.3
	Confined	0.7		0.8	1.0	1.2	1.5	1.8
	Unknown	-		-	-	-	-	-
	Domestic	2.5		3.0	3.7	4.5	5.4	6.6
	SUB-TOTAL	5.2		6.3	7.7	9.3	11.3	13.7
HAMILTON TOWNSHIP			18.4%					
GREAT EGG HARBOR	Surface	-		-	-	-	-	-
	Unconfined	0.7		0.8	1.0	1.2	1.4	1.6
	Confined	1.0		1.2	1.4	1.7	2.0	2.3
	Unknown	-		-	-	-	-	-
	Domestic	0.7		0.8	1.0	1.2	1.4	1.6
	SUB-TOTAL	2.4		2.8	3.4	4.0	4.7	5.6
	TOTAL	25.7		30.3	35.9	43.3	49.9	59.0

It is anticipated that substantial amounts of water will continue to be depletively and consumptively used in these three townships during the planning period. Table 13 estimates water demand for the three municipalities out to Year 2050. This projection employs a similar methodology used to estimate growth in the counties and watersheds of the Southeastern New Jersey Study Area. It assumes that demand will increase at a rate corresponding to the rate of estimated population growth. As Table 13 shows, water demand is projected to grow from 25.7 MGD to 59.0 MGD during the planning period –

[8] The ACMUA has reservoirs in two of these towns. However, due to the intermitten use of these reservoirs, no projections were made. These will be made in the comprehensive study.

a growth rate of about 130 percent. Egg Harbor Township is projected to withdraw about 67 percent of all water withdrawn by Year 2050.

It is possible that these projections may be conservative. Water allocations in the three municipalities have recently been proposed at approximately 7 MGD. That is more than was projected for Year 2015. Most of the water being requested would be from the water table aquifer. Clearly, water use and water demand projections reflect many uncertainties. See Section 9.1, Uncertainties, in this report for further discussion.

5.0 EFFECTS OF WITHDRAWALS AND HUMAN ACTIVITIES ON THE WATER RESOURCES OF THE REGION

The Southeastern New Jersey Study Area appears to be showing signs of stress on its water resources that often accompany high rates of development. These stresses are the result of depletive and consumptive water uses associated with development. Significant amounts of water that are depletively or consumptively withdrawn from a watershed or a confined aquifer will result in streamflow reductions and/or cause saltwater intrusion. These effects are discussed below, by individual water source. It is important that these effects be quantified in a more comprehensive plan recommended by this report to determine their magnitude.

5.1 KIRKWOOD-COHANSEY AQUIFER

If environmental and ecological resources are to be adequately protected, it is paramount to protect stream baseflow. A loss in baseflow can cause significant ecological changes both in the freshwater stream itself due to the lack of water depth necessary to support higher-order finfish, and consequential loss of habitat in near-stream environs including wetlands (Stockton, Pinelands Comprehensive Management Plan, 1979). Stream baseflow can be affected by human activities. Development of a watershed can affect baseflow by removing wastewater from a watershed; reducing the amount of recharge to an aquifer through increases in impervious cover; and, increasing ground water withdrawals. Reduced baseflow in turn may degrade or destroy habitat for aquatic animals, reduce the amount of water available to dilute contaminants in the stream, and reduce the amount of water available to users downstream who depend on the stream for water supply (USGS, 2000).

Based on current and projected demand, the NJDEP is concerned that excessive withdrawals from the water table aquifers in the Mullica River, Great Egg Harbor River and Southern Barnegat Bay watersheds may be contributing to the effects discussed above. When depletive and consumptive uses are substantial in a watershed, in conjunction with the other effects associated with dense development, even a moderate drought can result in significant impacts to natural resources. A major drought can thus have severe consequences to these resources under these circumstances.

In addition, there is also concern that excessive withdrawals may be dewatering valuable wetlands and causing estuarine and aquifer saltwater intrusion. Regarding the latter impact, changes in the natural freshwater inflow to estuaries can have significant impacts on the health and distribution of flora and fauna in the receiving waters. Changes in the timing or quantity (too much or too little) of freshwater inflows can adversely affect fish spawning, shellfish survivability, bird nesting, seed propagation, or other seasonal activities of fish and wildlife. High salinity associated with drought has the greatest effect on larval and juvenile stages of species. Increases in salt concentrations can negatively impact shellfish growth rates and susceptibility to dermo, MSX and other parasites. Physiological limits, as well as increased disease and predation, can result in higher natural mortality due to drought conditions.

Sufficient freshwater inflow is needed to maintain the health of estuarine plants. Seagrasses require a mixed freshwater/saltwater environment to survive. Seagrass habitat protects juvenile fish, provides bird-nesting areas, and is an important food source for both fish and other marine animals. In addition to changing the salinity regime in receiving waters, excessive withdrawals from water table aquifers cause localized saltwater intrusion in small coves and channels. Decreasing water flows allows the tide to push saltwater farther upstream, into freshwater habitats. Most freshwater plants and animals are not tolerant of salty water (USEPA, 1997).

Figure 8 (next page) illustrates how substantial pumpage of a shallow water table aquifer by public water systems within a watershed, and the subsequent depletive removal of this water by sewers and excessive consumptive uses such as irrigation, can reduce the amount of water that naturally discharges into local water bodies.

The upper portion of Figure 8 represents a cross section of a water table aquifer/stream relationship under predevelopment conditions (i.e., there are no withdrawals or other effects associated with human activities). As precipitation occurs, a portion will flow overland to the stream as runoff, and a portion will recharge the aquifer and later discharge from it to the stream as baseflow. In the Southeastern New Jersey Study Area, the vast majority of precipitation is recharged into the aquifer due to the high permeability of its soils. Streamflow will generally fluctuate with the seasons. During the colder months, streamflow is generally much higher since there is little evapo-transpiration. During the summer months, streamflow will be significantly reduced by evapo-transpiration. Most, if not all, of ground water recharge is “consumed” by evapo-transpiration during this period. During this period, much of baseflow is made up of ground water that was recharged to the aquifer during the winter months.

As the middle portion of Figure 8 shows, when a potable supply well is placed in the aquifer, and water from the well will be conveyed elsewhere or “lost” through residential/commercial irrigation activities, a cone of depression will form as water that previously flowed toward the stream is removed, and overall stream discharge is reduced. This loss is compounded in the summer months by the natural loss due to evapo-transpiration. It is further intensified by other factors such as if the well pumps substantially more during the warmer months, the amount of upstream drainage area contributing baseflow, the magnitude of other upstream depletive and consumptive uses, and whether the well is in close proximity to the stream.

As the lower portion of Figure 8 illustrates, when pumpage is substantially increased in the future, water in the stream will also be substantially reduced even further as some of it is induced or “pirated” into the aquifer toward the well. In cases where pumpage is very great, ground water can even be pirated from an adjacent watershed, reducing streamflow in that watershed. These phenomena are significantly exacerbated during periods of low rainfall when streamflow is normally low. In these cases, streams can be converted from those that were continuously "gaining" ground water prior to substantial pumpage, to streams that are "losing" flow during low rainfall periods and significant pumpage. There are numerous examples of regions where excessive ground water pumpage has resulted in streams that were once free flowing during the summer being converted to streams that only flow during significant storm events (e.g., Long Island).

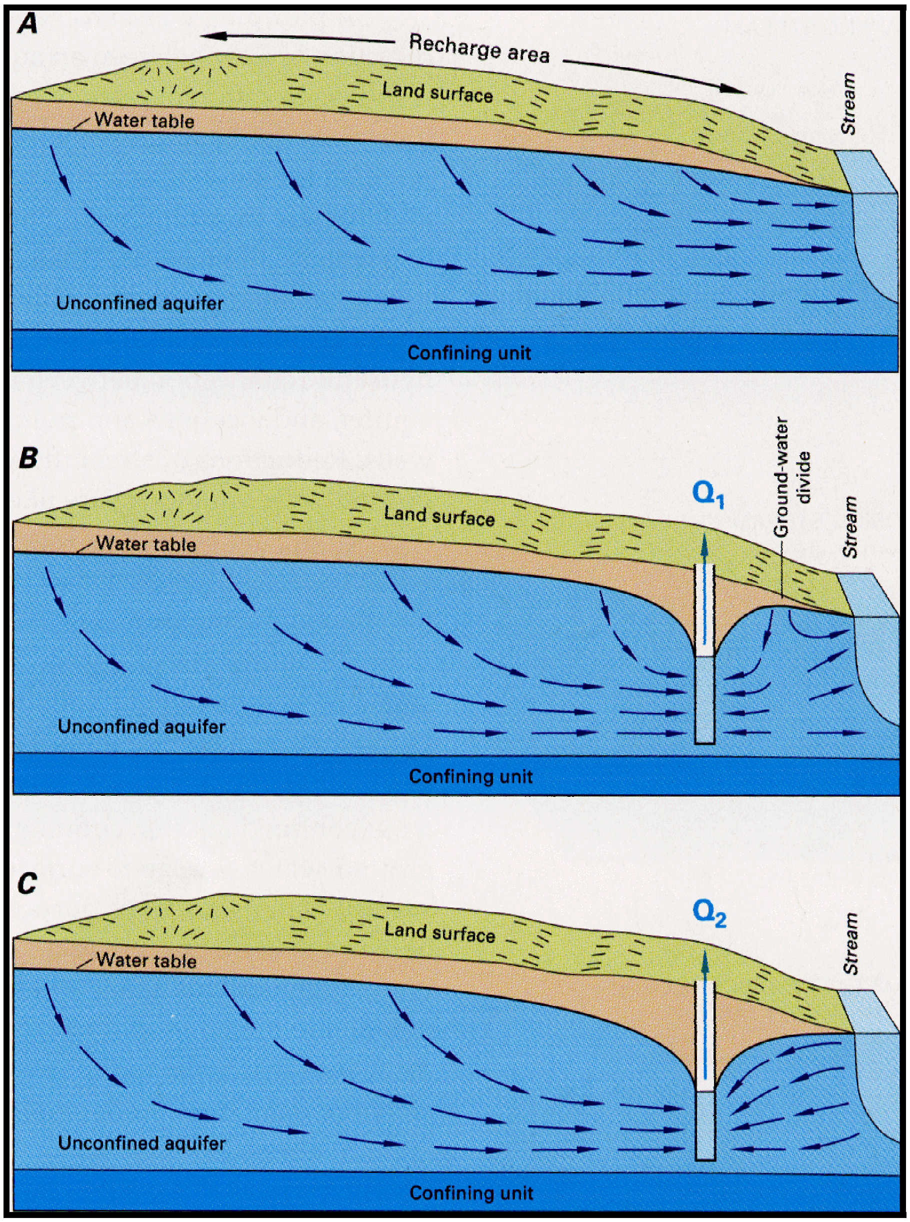

Figure 8. Example of the Effects of Depletive Withdrawals from the Kirkwood-Cohansey Water Table Aquifer on Streamflow under Predevelopment, Current and Future Development Conditions

If intense agricultural use and consequent evaporative losses accompany this phenomenon, these effects may be magnified. Similarly, substantial quantities of water that are diverted and stored for agricultural purposes during the fall could result in streamflow diminishment during this period. The covering of recharge areas by impervious surfaces that accompany development has also been shown to reduce stream baseflow.

As suggested above, streamflow diminution is most pronounced during summer/fall months when recharge is low, evapo-transpiration is most intense and stream discharge is naturally low (Maidment, 1992). During the winter/spring months stream discharge is generally several times greater, primarily due to low evapo-transpiration. Consequently, withdrawals that can significantly reduce streamflow during summer and fall may have minimal effect during the winter and spring. The water table aquifer, or surface water primarily made up of ground water discharged from the water table aquifer, can thus be a valuable seasonal source of water.

Observation wells used by the USGS to monitor the Kirkwood-Cohansey water table aquifer in the Hamilton Township area showed record low ground water levels during the 2001-2002 drought (see Figure 9). This phenomenon is a result of lower than normal precipitation coupled together with increasing ground water withdrawals needed to meet water supply demand (Navoy, 2001). The figure shows a continuous decline in ground water levels during the ten-year period. The Kirkwood-Cohansey water table aquifer is the primary source of base flow in the Southeastern New Jersey Study Area streams.

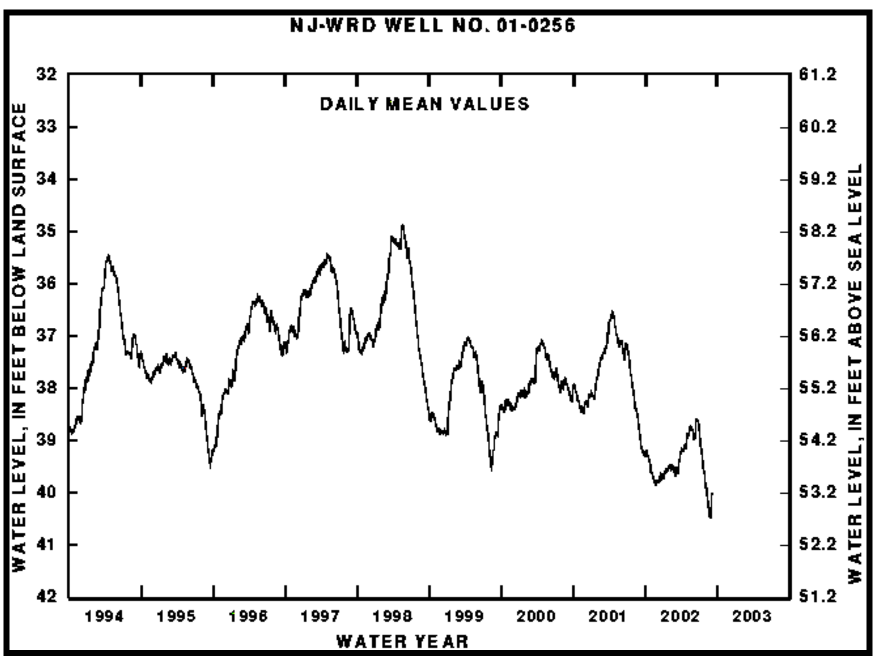

Figure 9a. Ten-year Hydrograph of Daily Mean Water Levels for Each Month of the Scholler 1 Observation Well That Is Screened in the Kirkwood-Cohansey Aquifer in Hamilton Township, Atlantic County (USGS, 2002)

Consequently, record low water table levels observed in 2002 will also have manifested themselves in severe low stream flow. Since the population in Hamilton Township increased from about 16,000 to more than 20,000 between 1990 and 2000, it is fair to conclude that increased demand in the Hamilton Township contributed to this trend.

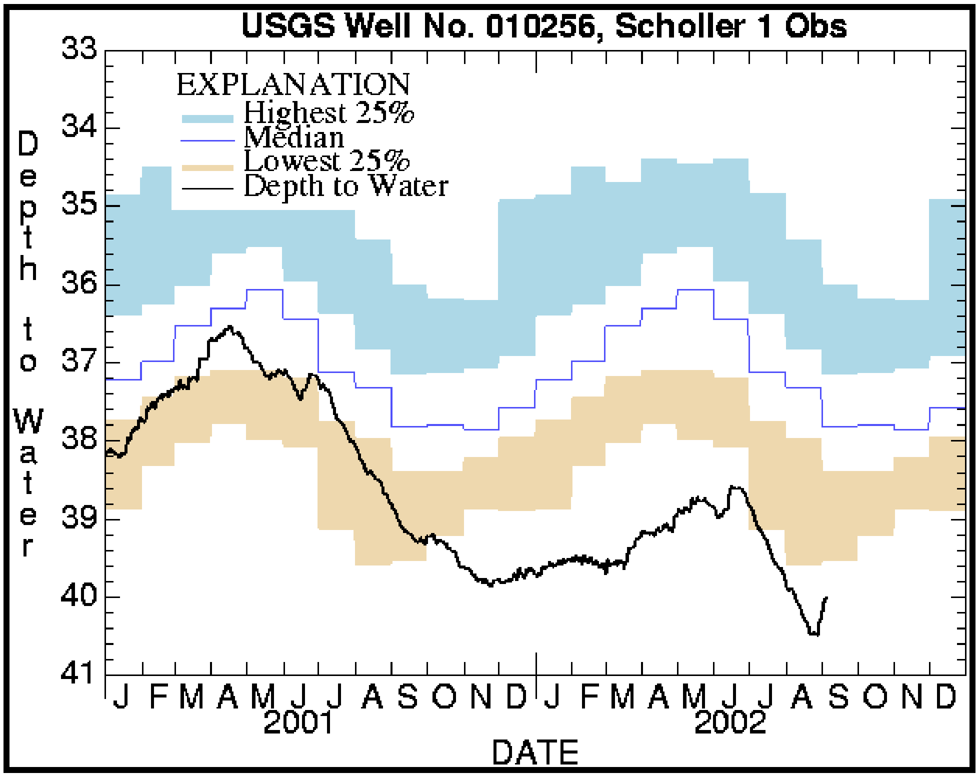

Figure 9b. Recent Hydrograph and Statistical Summary of Daily Mean Water Levels for Each Month of the Scholler 1 Observation Well That Is Screened in the Kirkwood-CohanseyAquifer in Hamilton Township, Atlantic County (USGS, 2002)

While the 2002 observations are not necessarily indicative of a long-term trend, these observations further illustrate the increasing susceptibility of the water resource to stress during periods of lower than average precipitation. However, when considered together, the observed water table and stream flow depletion during the 2002 drought being below those recorded during the drought of record, and the fact that current withdrawals exceed the water supply planning capacity of the aquifers (see below), it appears that regional water supply demand may already exceed the dependable or sustainable yield of these aquifers. Increases from these existing withdrawals and new withdrawals will aggravate these conditions.

A recent investigation estimated whether changes in streamflow have occurred over time in four coastal watersheds, including the Great Egg Harbor River watershed (USGS, 1992 and USGS, 1995). Trend analysis showed that streamflow within the Great Egg Harbor River watershed has been continuously declining during summer and fall, the seasons of lowest discharge, during the period 1970 to 1989. This same period is also characterized as one of substantial growth and consequent depletive sewering in the watershed. Lowest annual 183-day mean discharge at Folsom has declined at an average yearly rate of approximately 1.2 MGD, from about 76 MGD to 50 MGD, for this period. Figure 10 illustrates this trend in declining discharge. These findings are significant; the cause(s) of these declines needs to be further investigated.

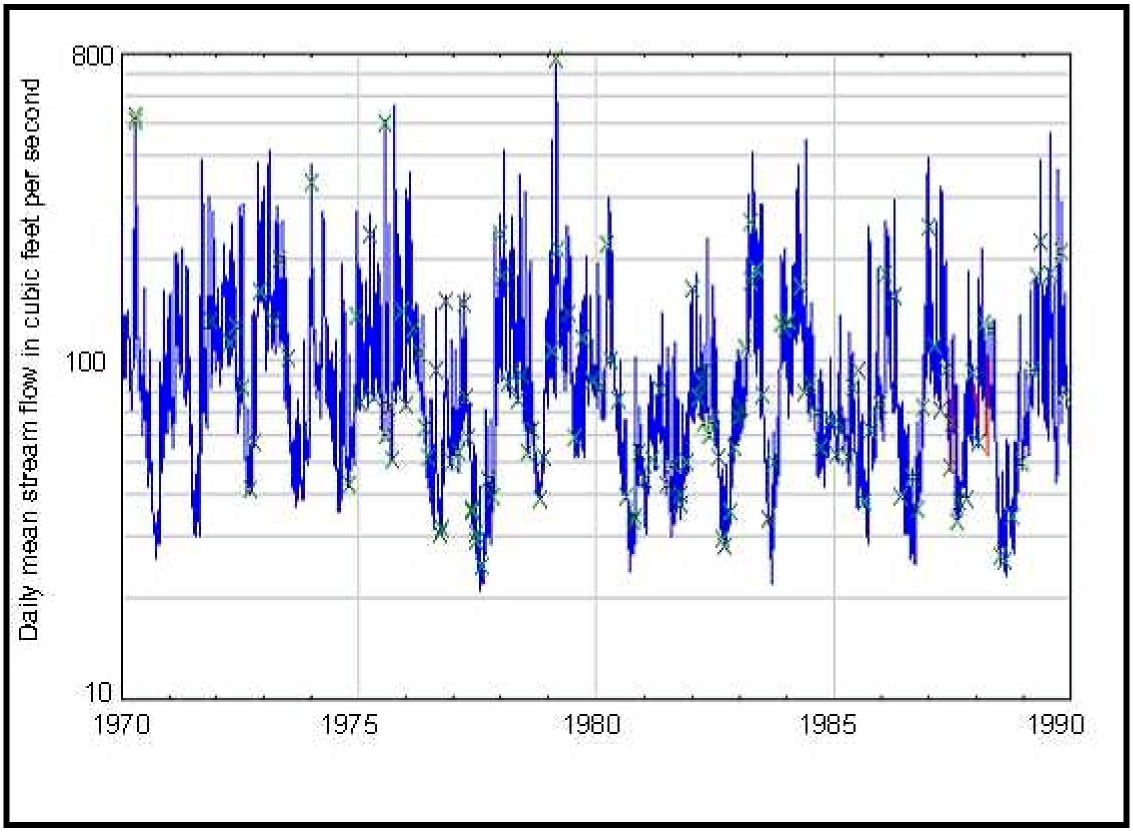

Figure 10. Trend in Lowest Annual 183-day Mean Discharge in the Great Egg Harbor River at Folsom, 1970-1989

The Great Egg Harbor River has been identified as a potential alternative water supply in the URS reports for the Atlantic County Study Area. In addition, the Great Egg Harbor River estuary (and Mullica River estuary) is a prime source of hard clam, blue crab, white perch and other marine life that are quite susceptible to minor changes in salinity. Alterations of the natural flow regimes in the tributaries can have significant effects upon the water quality and health and distribution of living resources in the receiving estuaries (USEPA, 1997).

Investigations in similar hydrologic settings in New Jersey are tentatively concluding that streamflow reductions can be approximated as proportional to the quantity of the withdrawal from the shallow water table aquifer on a regional basis (i.e., for every 1 MGD depletively withdrawn from the water table aquifer there will be an approximate reduction of 1 MGD to surface waters, such as streams, lakes and estuaries). As described below, substantial pumpage of underlying confined aquifers induces the downward flow of water from water table aquifers that otherwise would discharge to surface water bodies. A recent comprehensive USGS investigation in the Toms River, Metedeconk River and Kettle Creek watersheds in Ocean County estimated that current depletive withdrawals from the Kirkwood-Cohansey aquifer in those drainage basins, in conjunction with the loss of recharge as a result of development, has resulted in stream (long-term, average) baseflow reductions of up to 12 percent (USGS, 1997). The quantity of the baseflow reduction is roughly equivalent to the quantity depletively withdrawn from the water table aquifer in each of those watersheds. Since long-term average and seasonal baseflows are substantially larger than streamflow during drought conditions, the effects of depletive withdrawals can be anticipated to be even more significant during drought periods.

Table 14 was developed as a planning level tool to estimate the magnitude of depletive and consumptive uses in the Southeastern New Jersey Study Area with regard to their potential effect on low streamflow periods. In general, the greater the amount of depletive and consumptive use in a watershed in comparison to historical low stream discharge in that watershed, the greater the severity of streamflow reductions as a consequence of those uses. For example, depletive and consumptive uses that are near or exceed low streamflow can be expected to nearly dry up or even totally dry up a stream during drought.

The MA7CD10 (minimum average seven consecutive days with a statistical recurrence interval of ten years) flow is typical of flow conditions during drought. Essentially, this is the amount of low stream base flow that can be statistically expected for one week during a decade. Because base flow has an inverse relationship to groundwater withdrawals, water use that exceeds base flow within a stream's watershed could essentially dry up the stream under drought conditions. This condition would significantly affect the ecology of perennial streams. Table 14 extrapolates the "total" MA7CD10 for each of the watersheds based on the most downstream gauging station, and compares that flow with current and projected peak withdrawal period depletive and consumptive uses (from Table 12).

TABLE 14

COMPARISON OF PEAK DEPLETIVE AND CONSUMPTIVE USES TO LOW STREAM FLOWS IN THE SOUTHEASTERN NEW JERSEY STUDY AREA

WATERSHED	WATERSHED AREA (SQ. MILES)	MA7CD10 FOR WATERSHED (MGD)	YEAR –2000 DEPLETIVE-CONSUMPTIVE USES (MGD)	YEAR –2050 DEPLETIVE-CONSUMPTIVE USES (MGD)
MULLICA	762	160.0	114.3	185.9
CAPE MAY	341	78.4	5.3	7.0
GREAT EGG	347	86.8	49.4	71.7
SO. BRNGT.	337	138.2	6.4	13.8

During the severe drought of 2001-2002 flow in many of the streams in the Southeastern New Jersey Study Area declined to less than the MA7CD10; several streams experienced record low flows substantially lower than the MA7CD10. Depletive and consumptive uses undoubtedly played a significant role in streamflow reductions in some streams in the Southeastern New Jersey Study Area during the recent drought. The recommended water supply feasibility study will evaluate the severity of streamflow depletion as a result of excessive withdrawals.

As shown above, these current uses in the Mullica River watershed represent a major fraction of the MA7CD10, and could substantially exceed its low flow by the end of the planning period. The preponderance of unconfined aquifer and surface water withdrawals is associated with the agricultural industry and to a lesser degree with potable supply withdrawals. Theoretically, it appears that there would be little if any freshwater flowing out of the watershed during extreme drought by the end of the planning period if the projections turn out to be accurate. Since the majority of wells are located in the upper half of the watershed (see Figure 5), however, it is more likely that streamflow depletion will be more severe and last for longer durations in this portion of the watershed, especially upstream of the Batsto area. There should be some recovery in flow in the eastern half of the watershed. In either case the magnitude of current and projected depletive uses are quite significant in the Mullica River watershed. This needs to be further investigated.

According to Table 14, the Great Egg Harbor River watershed also appears to be highly susceptible to streamflow reductions associated with potable supply withdrawals and to a lesser degree from agricultural withdrawals. Present depletive and consumptive uses represent more than one-half the MA7CD10 and are projected to represent about 80 percent of this low flow by the end of the planning period. As previously discussed, the townships of Egg Harbor, Galloway and Hamilton are responsible for nearly half of the depletive and consumptive uses in the watershed. Due to the high degree of anticipated growth in these municipalities, these uses are expected to represent nearly 80 percent of depletive and consumptive use in the watershed by 2050. Based on Figure 5 (in Section 4.2), most of the agricultural withdrawals are in the headwaters and most of the potable withdrawals are in the coastal area. This would lead one to speculate that streamflow depletion may be somewhat severe in the headwaters, recover to some degree in the middle of the watershed, and again intensify in the coastal area. Regarding the latter, in addition to streamflow depletion, the induction of brackish water from coastal bay areas by excessive potable supply pumpage may be a concern to aquatic systems. In addition, many of the depletive and consumptive uses are upstream of the ACMUA's reservoirs and, thus, affect the safe yield of these supplies.

The Cape May County and Southern Barnegat Bay watersheds appear to be significantly less vulnerable to regional streamflow depletion. However, this analysis is based on overly broad analytical units. On a sub-watershed basis, significant reductions in base flow due to water withdrawals may occur. In addition, there is the concern for saltwater intrusion as a result of pumpage from the confined aquifers in these two watersheds. These are addressed in the next section. All of these potential effects will need to be further investigated in the comprehensive water supply plan recommended by this report.

This assessment did not consider the effects on the water table aquifer as a result of pumpage from the confined aquifers. The 1996 Plan showed that a considerable amount of water is induced from the water table aquifer from deep aquifer pumpage (see Figure 17). Future analysis will need to take this into consideration.

The recent assessment conducted by the USGS during the drought of 2001-2002 illustrates the potential effects that depletive and consumptive uses might have on low streamflow in the region. Figure 11 represents the hydrograph and statistical analysis plot of streamflow at the Great Egg Harbor River at the Folsom gauge station. The figure shows that the river declined below the MA7CD10 for a few days in the summer of 2001 and for a number of days in the summer of 2002. During the latter period, new low flows were recorded. The USGS concluded that these circumstances were the result of the prevailing drought conditions at the time and the influence of pumping (Navoy, 2001).

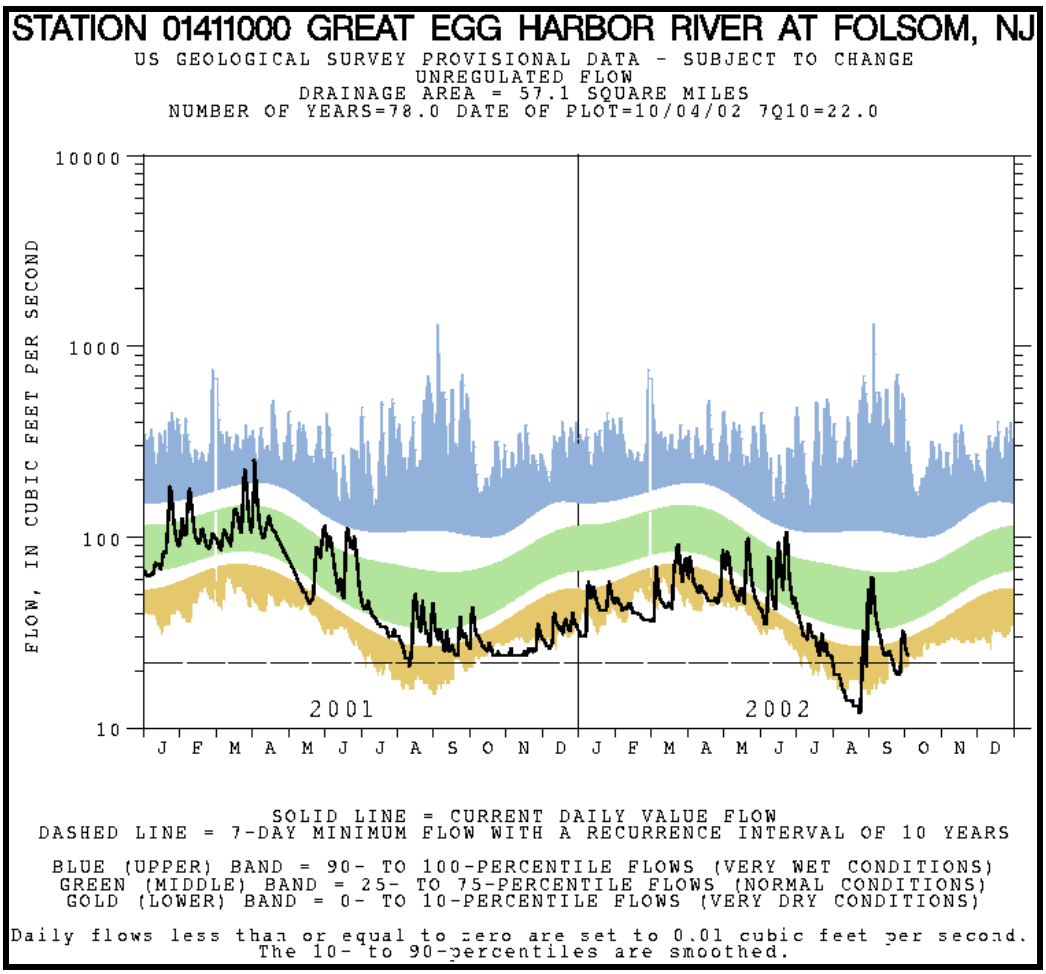

Figure 11. Hydrograph and Statistical Analysis Plot of Streamflow at the Great Egg Harbor River at Folsom, Atlantic County

A similar phenomenon was observed on the Mullica River at Batsto during the recent drought. As Figure 12 shows, streamflow declined below the MA7CD10 and reached new record low flows for a few days in the summer of 2001 and nearly declined below the MA7CD10 during the summer of 2002. Since depletive and consumptive water uses result in streamflow declines, these uses undoubtedly contributed to these flow conditions.

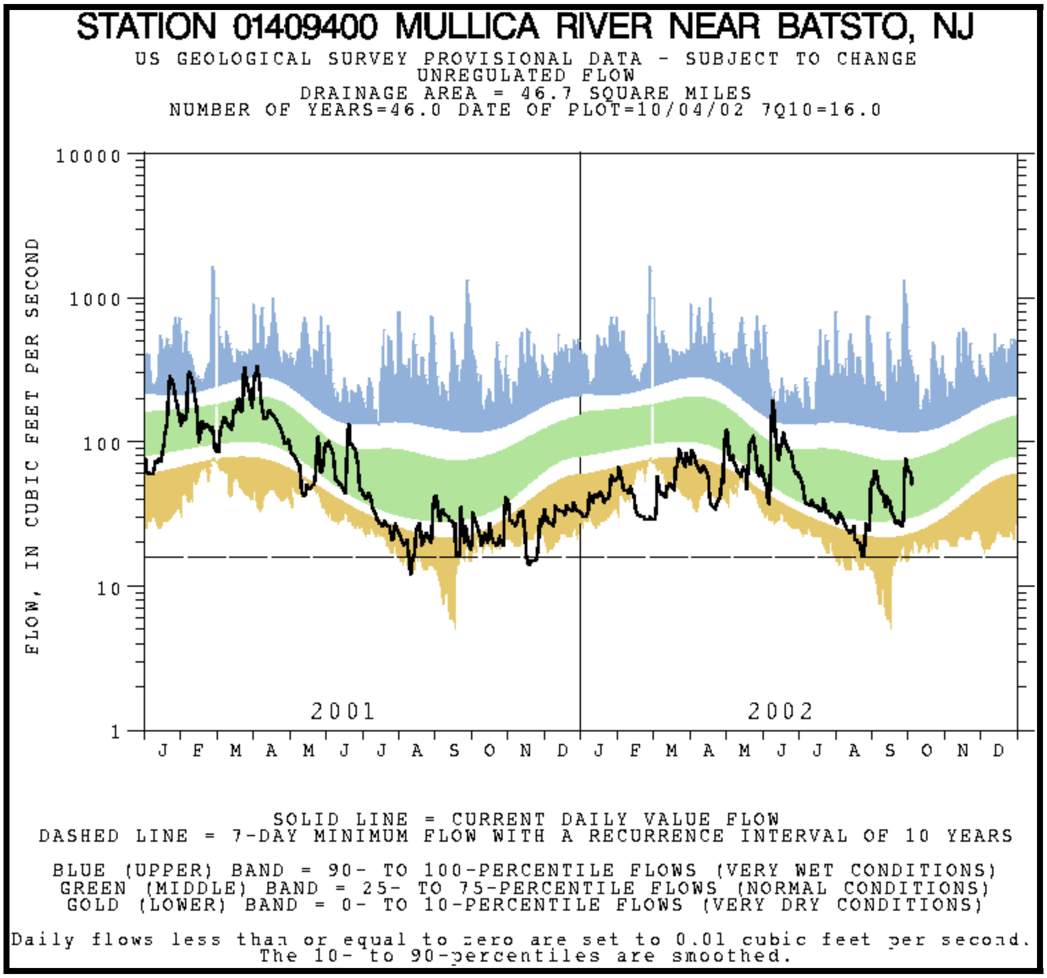

Figure 12. Hydrograph and Statistical Analysis Plot of Streamflow at the Mullica River near Batsto, Atlantic County (USGS, 2002)

The intensity of domestic wells in the Southeastern New Jersey Study Area also deserves to be assessed, in conjunction with public water supply, agricultural and other water use category withdrawals. As shown earlier in Table 4 (in Section 4.2), domestic wells withdraw 22.5 MGD or about 12 percent of all water withdrawn in the study area. This amount is projected by this report to increase to 36.8 MGD by Year 2050. In many areas, private wells are concentrated in the study area. In these cases, they may be contributing to streamflow depletion, if excessive amounts of water are being used during the summer for irrigation.

The NJDEP has made planning estimates of water availability in the Mullica River, Great Egg Harbor River, Cape May and Southern Barnegat Bay watersheds as part of the last NJ Statewide Water Supply Plan (NJDEP, 1996). Based on regional ground water supplies that have previously experienced major deficits, for planning purposes the NJDEP assumes that 10 percent of a watershed's natural ground water recharge is available in coastal southern New Jersey for depletive and consumptive water supply purposes to minimize the potential for saltwater intrusion and streamflow depletion. The 1996 Plan emphasized that these thresholds were not definitive statements of the dependable yields of these supplies. Rather, they are to be used for planning purposes; as demand approached the threshold, more comprehensive investigations were to be conducted to more reliably estimate ground water availability. Table 15 provides estimates of available water and compares these estimates to water demand in each of the region's watersheds. As previously described, the majority of water in the Southeastern New Jersey Study Area is used in a depletive and consumptive manner as a result of the significant amount of irrigation activities and the fact that much of the coastal area is served by regional sewers.

TABLE 15
COMPARISON OF WATER DEMAND TO WATER AVAILABILITY IN THE SOUTHEASTERN NEW JERSEY STUDY AREA (MILLION GALLONS PER DAY – AVERAGE)

WATER-SHED	1996-2000	1990-2010 DEMAND GROWTH RATE PER DECADE	PLAN-NING YIELD	2010	2020	2030	2040	2050
Mullica River	95.3	10.2%	63.5	105.6	116.3	128.2	141.3	155.7
Cape May	24.1	5.8%	29.0	25.5	26.9	28.5	30.2	31.9
Great Egg	55.84	7.6%	31.1	60.1	64.7	69.6	74.9	80.6
So. Barnegat	19.38	15.3%	25.0	22.3	25.8	29.7	34.3	39.5
TOTAL	194.6	9.7%	148.6	213.4	234.1	256.9	281.8	309.2

Thus, unless the NJDEP's present planning thresholds are largely inaccurate, current withdrawals (194.6 MGD) presently exceed available water (148.6 MGD) in the Southeastern New Jersey Study Area as a whole. The current region-wide planning deficit is about 46 MGD; it is projected to increase to about 160 MGD by Year 2050. Specifically, the Great Egg Harbor River watershed is in current (and perhaps severe) deficit. Withdrawals from Egg Harbor, Galloway and Hamilton townships substantially contribute to the deficit, since their withdrawals represent more than half of all the ground water withdrawals in the entire watershed. In fact, current withdrawals from these three towns consume almost all the available water in the entire watershed. The Mullica River also is in a relatively significant planning deficit while the Southern Barnegat Bay and Cape May Coastal watersheds are anticipated to be in deficit during the planning period.

5.2 LIMITATIONS OF PLANNING THRESHOLDS

There are several factors that were not considered when the NJDEP developed the above planning thresholds:

- First, the location of the naturally occurring saltfront with respect to confined aquifer withdrawals was not factored into the development of the thresholds. The Cape May watershed is an example of the weight of this determinant in overall water availability. While Cape May might not be in planning deficit, most water resource professionals would agree that current demand has already exceeded availability in this watershed. This same concern might exist in the Southern Barnegat Bay watershed. Many of its confined aquifer withdrawals on both the barrier islands and mainland may be located not so distant from the saltfront.
- Second, the thresholds did not consider the location of water table aquifer withdrawals in the watersheds. A watershed could theoretically be in a planning surplus, but if there are numerous withdrawals from the unconfined aquifer in the headwaters or near the coast, streamflow depletion and saltwater intrusion could be problematic. Based on Figure 5, stream headwater depletion may be an issue in the Mullica River and Great Egg Harbor River watersheds due to agricultural withdrawals, while the inducement of brackish water as a result of ground water pumpage may be an issue in the Mullica River and Southern Barnegat Bay watersheds due to public supply withdrawals.
- Third, the seasonal demand of withdrawals was not factored into the availability thresholds.
- Fourth, the thresholds compared average demand to long-term average recharge estimates. When combined, these two factors play a major role in overall water availability. As previously discussed, there is often a wide fluctuation in winter and summer demand; summer demand for some water use categories are twice or more that of winter. During drought warning periods, demand typically is even greater. Simultaneously, recharge during periods of low precipitation is substantially lower than average conditions, resulting in lower than normal streamflow. Both these factors consequently can lead to excessive streamflow depletion.
- Fifth, some withdrawals are largely consumptive during the summer months, but generally non-consumptive during other parts of the year. For example, cranberry withdrawals are primarily consumptive during the growing season when water is used for irrigation, but not very consumptive in the fall and winter when withdrawals are used for bog flooding and frost control, respectively. However, these latter activities are considered largely consumptive because all water withdrawals are averaged.

As part of the next NJ Statewide Water Supply Plan, the NJDEP will be developing comprehensive water budgets for all of the watersheds of the State, as well as minimum streamflow goals for various natural resources dependent on adequate amounts of freshwater. The budgets will estimate current and projected reductions in streamflow and compare those with the streamflow goals. It is anticipated that this task of the plan will be completed in 2004. The comprehensive water supply plan recommended by this report will build on these budgets in an effort to address the above uncertainties.

5.3 ATLANTIC CITY 800-FOOT SAND AQUIFER AND OTHER CONFINED AQUIFERS

Large-scale development and the consequent demand for large amounts of water along the Atlantic County coast have raised concern about the potential for migration of saltwater into the area's well fields in the Atlantic City 800-foot sand aquifer. Demand from confined aquifers, such as the Atlantic City 800-foot sand aquifer, is almost always depletive, since there is little opportunity to recycle water back into the supply.

The possibility of saltwater intrusion was evaluated as part of the Atlantic County Study Area Investigation through the construction of a ground water flow model by the USGS that is designed to simulate regional declines in ground water pressure levels in the aquifer under various withdrawal scenarios (USGS, 1990). The output from the model was subsequently used to analytically estimate the migration of the saltfront (250 mg/L of chloride). Two offshore wells were installed east of Atlantic City to determine water levels and to provide data to estimate the location of the saltfront. A sub-regional solute-transport model was more recently constructed by the USGS to estimate intrusion into the Atlantic City 800-foot sand aquifer in southern Cape May County (Voronin, Spitz and McAuley, 1996).

Prior to the development of this aquifer for water supply purposes, ground water pressure levels in the Atlantic City 800-foot sand aquifer were as high as 50 feet above sea level in the Atlantic County area (Voronin, Spitz and McAuley, 1994). This means that water rose nearly 50 feet above the surface when the first wells were constructed in the late 1800s in Atlantic County. The direction of ground water flow in this area was from the higher elevations of Cumberland, western Atlantic County, and Burlington and Ocean counties, where it is interconnected with the water table aquifer, to down-dip locations where it flowed upward into the overlying water table aquifer system on the mainland, as well as farther offshore where the discharge acted to retard saltwater from advancing into the aquifer at the Delaware Bay and the Atlantic Ocean (Figure 13 – left illustration).

In response to pumpage, however, a regional cone of depression has developed in the Atlantic City 800-foot sand aquifer that extends from southern Cape May to central Ocean County, a distance of over 50 miles (Figure 13 – right illustration). As shown in Figure 14, the cone is centered in the Absecon Island area where ground water pressure levels have declined to more than 110 feet below sea level. Between 1988 and 1993, the cone of depression declined one to nine feet in most areas throughout the aquifer (USGS, 1995). Between 1993 and 1998, ground water pressure levels in the aquifer declined an additional 11 feet in the Atlantic City area (USGS, 2001). Levels have declined to nearly 60 feet below sea level five miles offshore.

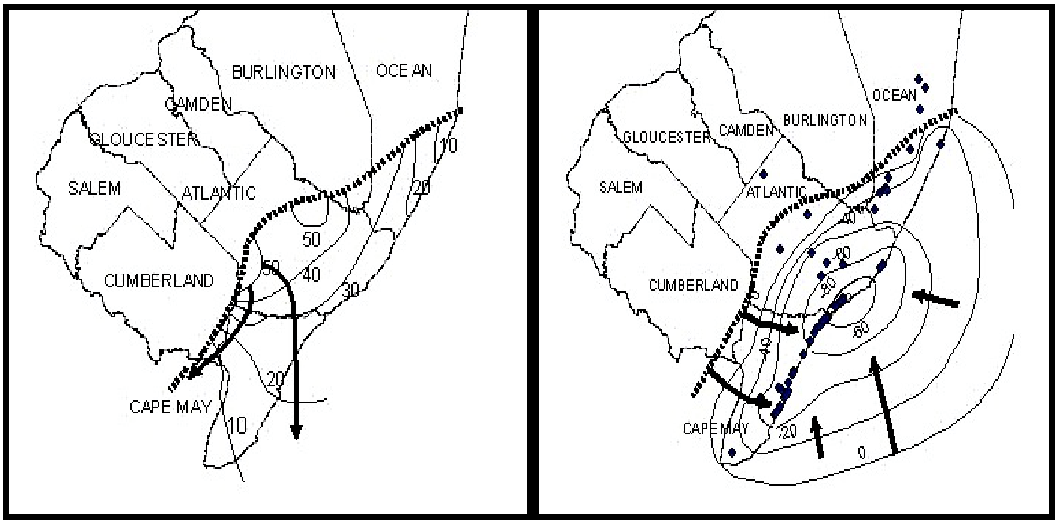

Figure 13. Predevelopment and Current Development Ground Water Pressure Levels and Direction of Ground Water Flow in the Atlantic City 800-foot Sand Aquifer

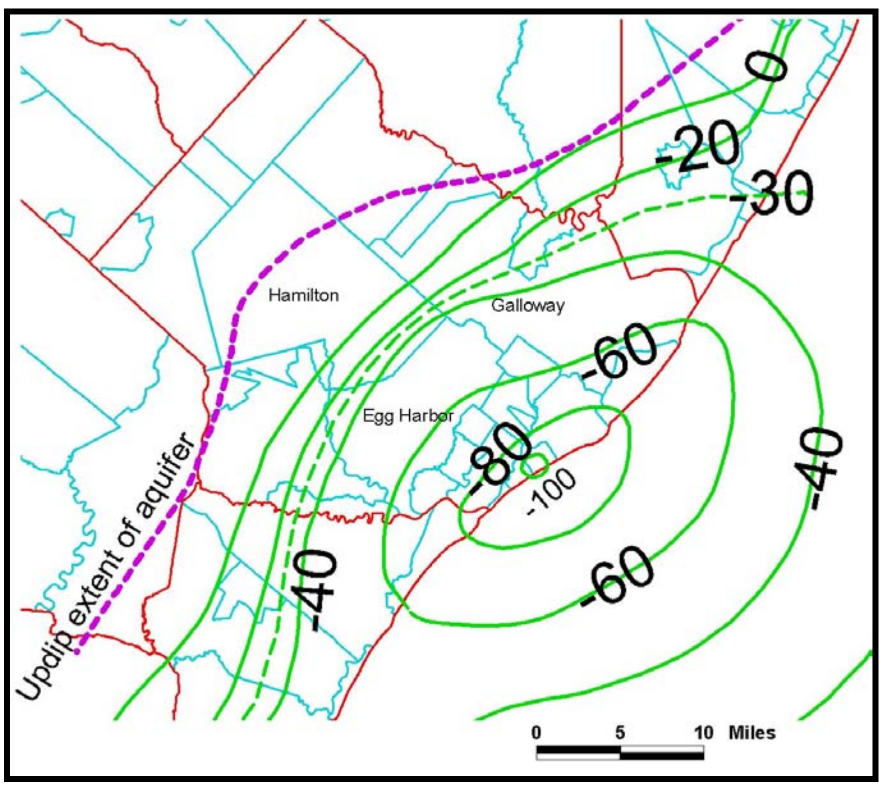

Figure 14. Ground Water Pressure Levels in the Atlantic City 800-foot Sand Aquifer in the Immediate Atlantic City Area (after USGS, Lacombe and Rosman, 2001, sheet 3)

As illustrated in Figure 15 (a – d), water pressure levels in four monitoring wells in the aquifer in Atlantic County have steadily declined during the period 1993 to 2002 alone in response to increases in pumpage (Navoy, 2002). Wells in Egg Harbor, Galloway, Somers Point and Atlantic City each year are setting or nearly setting a new record low in the summertime during this period. These declines are the direct result of depletive pumpage from the aquifer.

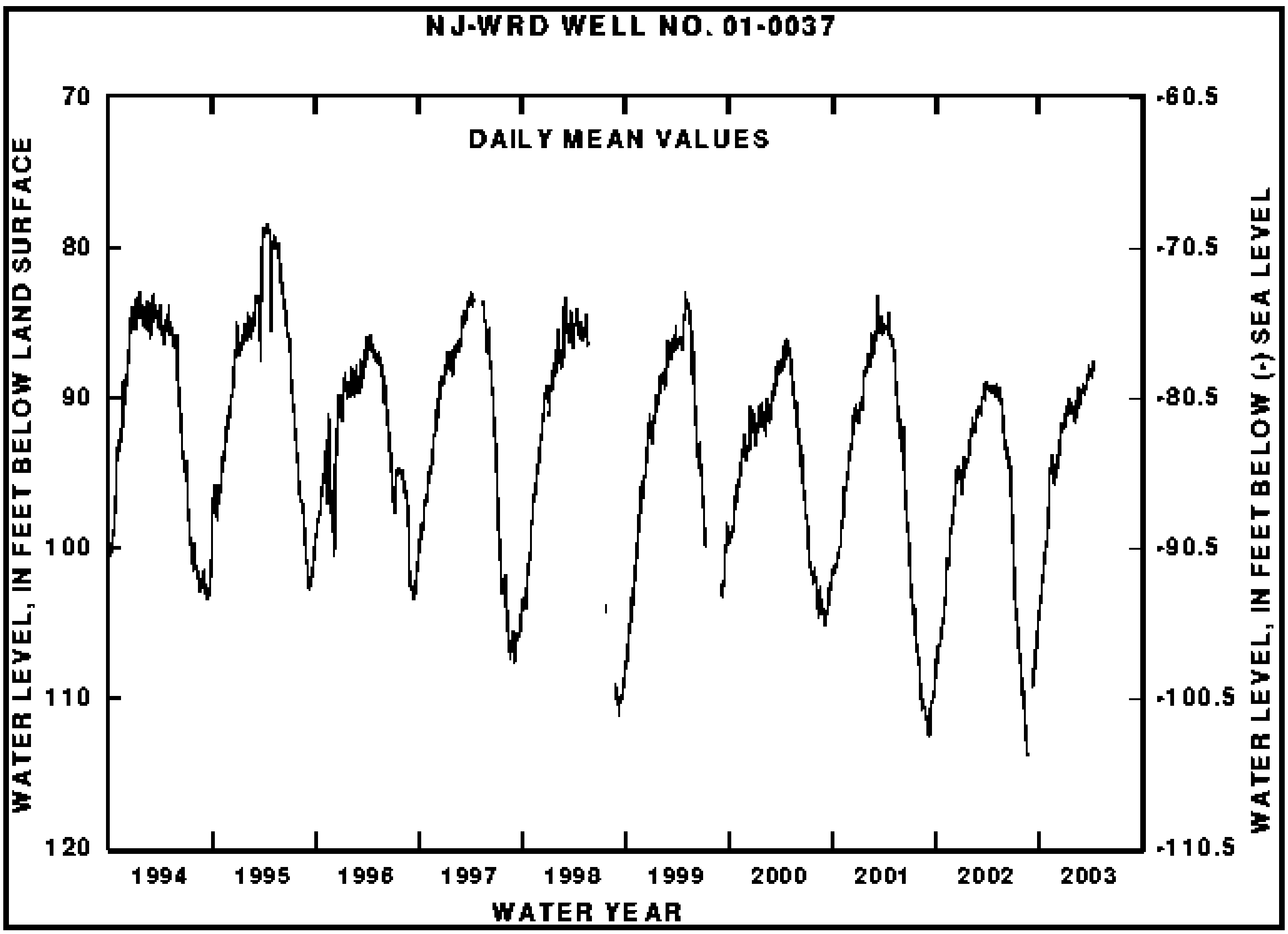

Figure 15a. Atlantic City

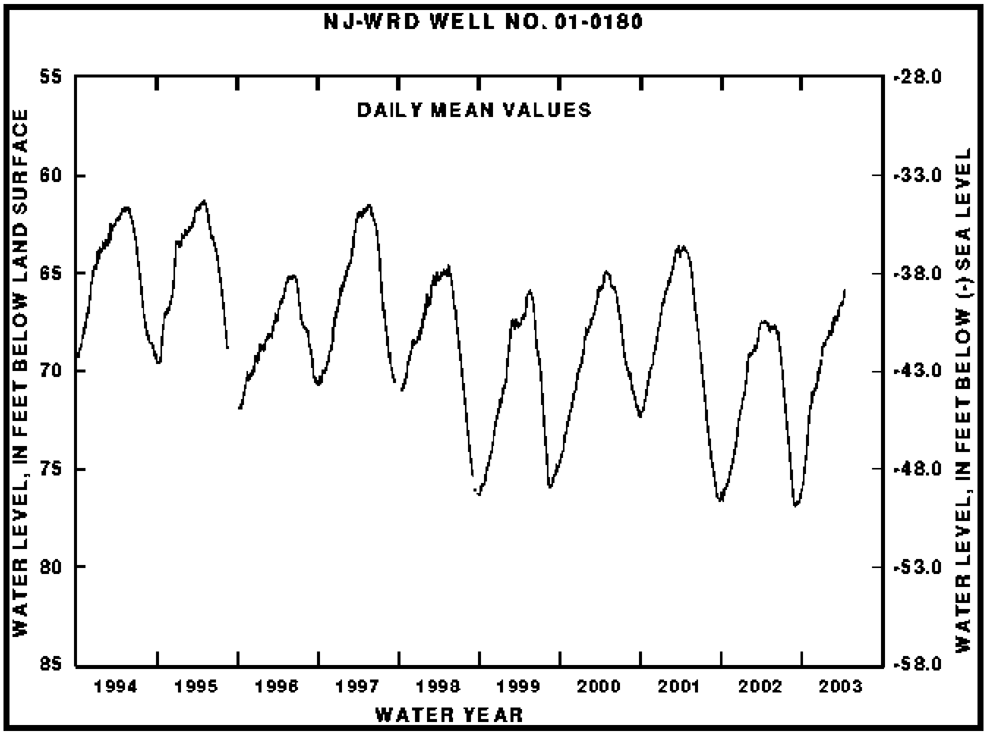

Figure 15b. Galloway

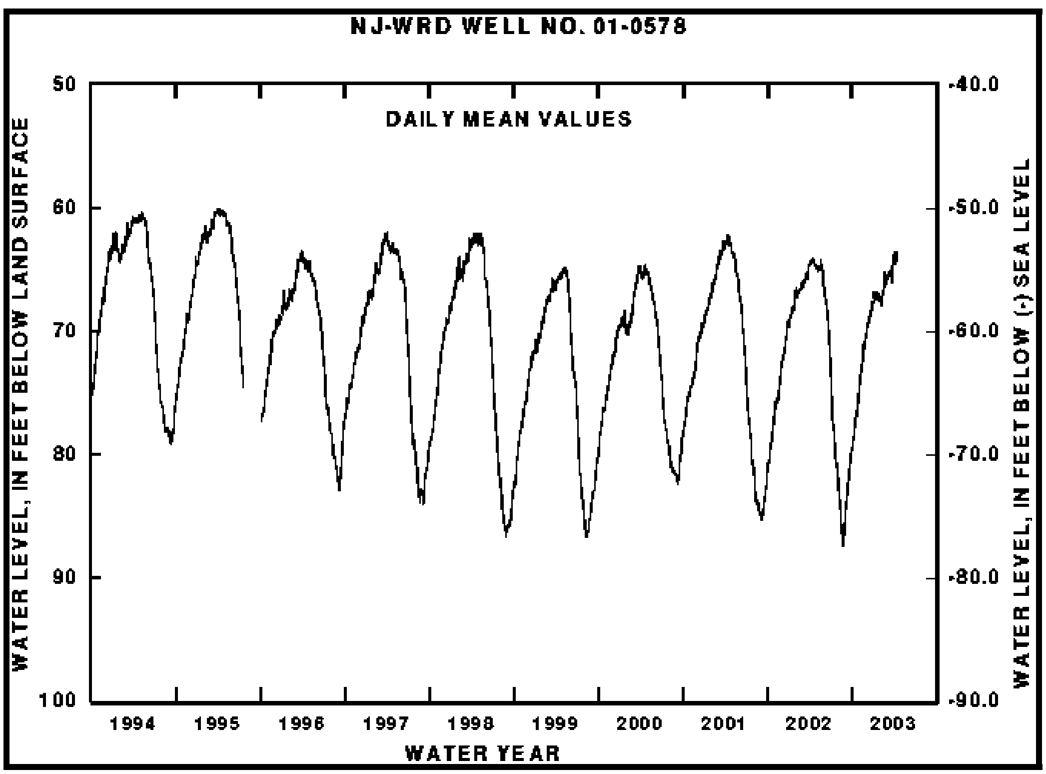

Figure 15c. Somers Point

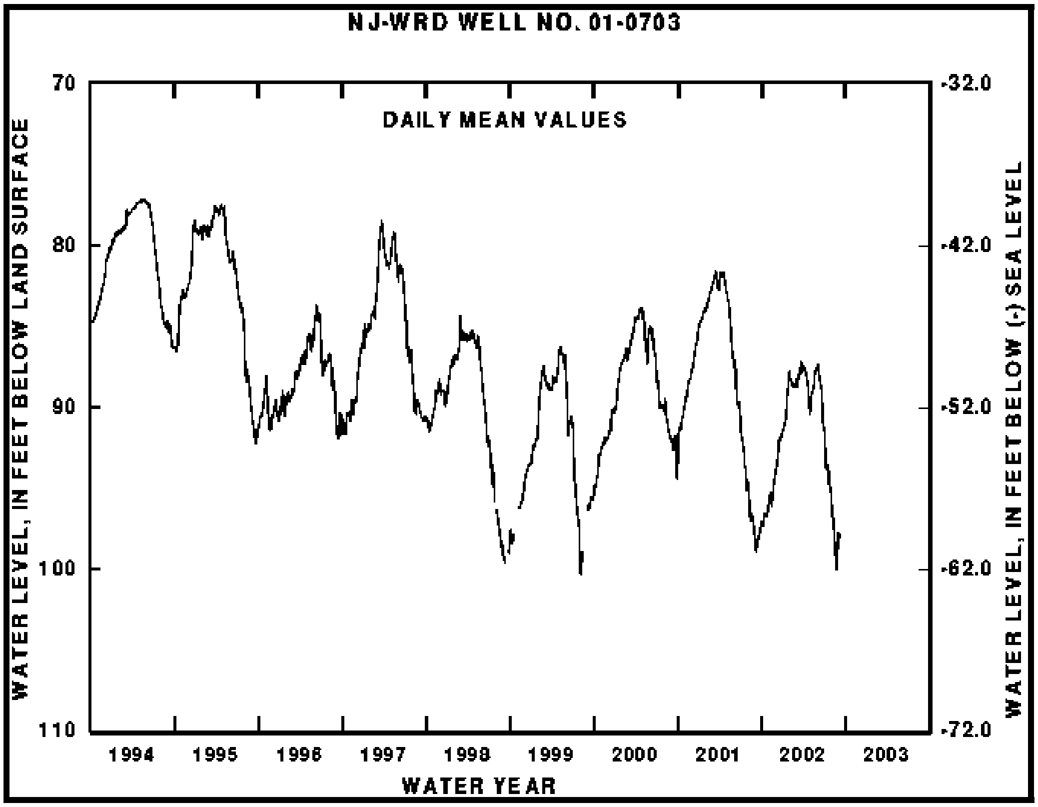

Figure 15d. Egg Harbor

In Cape May County, water levels declined to 95 feet below sea level in Ocean City and 50 feet below sea level in Stone Harbor by the year 1987. Water levels declined an additional ten feet in the Ocean City area between 1988 and 1993 (USGS, 1995) and an additional 11 feet five years later in 1998 (USGS, 2001). The historical data provide significant insight on how the aquifer responds to pumpage; as pumpage from the aquifer increases there is a corresponding decrease in ground water pressure levels. These declines are regional in nature and a consequence of pumping in all three counties; the depth is in response to the rate of local pumpage in conjunction with pumpage throughout the entire aquifer.

These increases in pumpage and subsequent ground water pressure level declines have resulted in a significant shift in ground water flow direction as well as a major alteration of the water budget of the aquifer, as compared to pre-pumping conditions (Figure 13 above). The present direction of offshore ground water flow has been reversed. Ground water no longer flows seaward; instead, ground water flows up-dip from beneath the Atlantic Ocean toward pumping centers and down-dip from the Delaware Bay toward pumping centers.

This shift in ground water flow direction has allowed the saltfront to advance into the aquifer. Results of an analysis of chloride concentrations in southern Cape May County indicate that the saltfront has advanced more than 6,500 feet northerly toward Stone Harbor pumping centers since 1958 (Lacombe and Carleton, 1992). Figure 16 illustrates the approximate location of the saltfront in southern Cape May County.

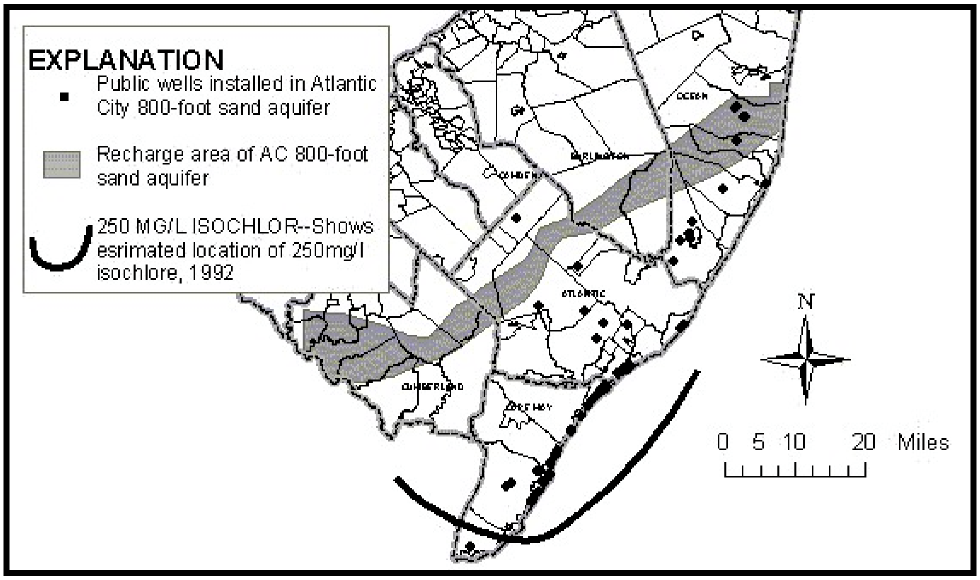

Figure 16. Estimated Location of the Saltfront in the Atlantic City 800-foot Sand Aquifer

Further, as Figure 17 illustrates, significant quantities of water are now induced or "pirated" from the overlying water table aquifer and confined Rio Grande aquifer, and from the underlying Piney Point aquifer, to the Atlantic City 800-foot sand aquifer.

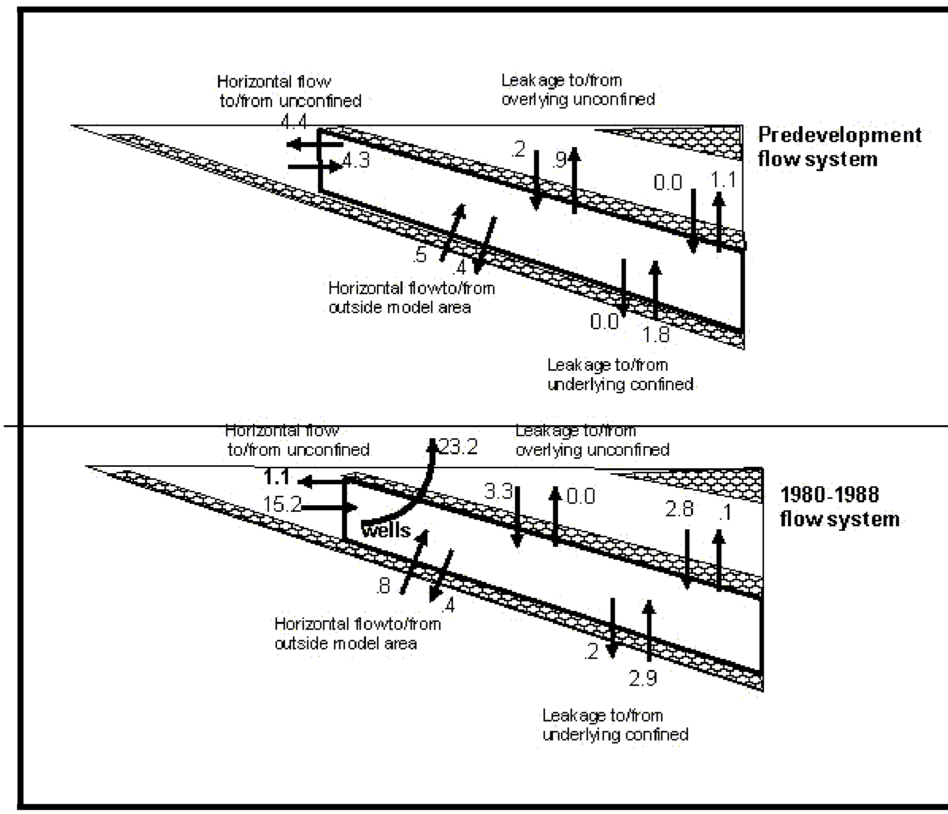

Figure 17. Predevelopment (upper figure) and 1980 to 1988 Current Development (lower figure) Ground Water Flow Budgets in the Atlantic City 800-foot Sand Aquifer

Presently, ground water flow from the up-dip area where the Atlantic City 800-foot sand is in direct connection with the water table aquifer to the west has substantially increased (from approximately 4 MGD to 15 MGD). Further, ground water in the Atlantic City 800-foot sand aquifer that once recharged the overlying water table aquifer (about 1.8 MGD) is reversed; about 5.0 MGD is being induced into the Atlantic City 800-foot sand aquifer from the water table aquifer. These phenomena may potentially exacerbate streamflow diminishment conditions in the Great Egg Harbor, Mullica and Maurice River watersheds as described in the previous section. Studies that are underway will verify the extent of this phenomenon.

The USGS ground water model and subsequent analysis shows the potential for further water pressure level declines in the region and for saltwater intrusion in the Atlantic City 800-foot sand aquifer in the next 50 years (1990 to 2040). Water pressure levels in this scenario are predicted to decline an additional 35 to 45 feet in the aquifer to about 150 feet below sea level, centered in the Atlantic City area and extending three miles offshore. In the Stone Harbor area, a decline of an additional 30 feet is predicted where ground water pressure levels would be approximately 80 feet below sea level.

These declines are anticipated to allow the continued, or long-term, inland migration of saltwater. The model estimates that movement toward Atlantic City wells will be between 700 and 3,100 feet between now and 2040. Since the saltwater front is approximately ten miles from these wells, saltwater intrusion should not be considered a problem during the planning period in the Atlantic City area (USGS, 1990). With regard to southern Cape May, a sub-regional model (developed specifically for this portion of the region) estimated that it would be at least one hundred years before Stone Harbor would be affected by saltwater intrusion, based on a 35 percent increase in demand. The saltfront is presently estimated to be about 20,000 feet south of Stone Harbor.

This predicted period of time when Stone Harbor's pumping centers would be affected by saltwater intrusion is complicated by the distance that the saltfront has migrated over the last four decades – more than 6,500 feet. The USGS has estimated that the historical rate of saltwater intrusion in southern Cape May was 154 feet per year. Assuming that this rate continued into the future, the saltfront would reach Stone Harbor shortly after Year 2100. It is essential to note that the historical rate of intrusion reflects historical rates of pumpage, and thus must be considered as a "conservative" rate when projecting it into the future, as pumpage increases. Nevertheless, Stone Harbor will not likely experience intrusion for at least several decades.

The predicted period of time when Stone Harbor's pumping centers would be affected by saltwater intrusion is further complicated by the water demand projections made in this report. Rather than the 35 percent increase in demand made as part of the USGS analysis, this report projects that confined aquifer withdrawals in the Southeastern New Jersey Study Area will increase by about 62 percent (see Table 8). While all new demand may not necessarily be from the Atlantic City 800-foot sand aquifer, it is essential that new analysis be performed to estimate the new arrival time for saltwater intrusion in Stone Harbor.

Although the above results and interpretation indicate that saltwater intrusion is a long-term issue in the Atlantic City 800-foot sand aquifer, they are symptomatic of an aquifer where demand has exceeded the ability of the resource to naturally renew itself. Indeed, even when demand previously stabilized for several decades, ground water pressure levels continued to progressively decline. This indicates that the aquifer is not in equilibrium with the demand that is presently placed upon it. Therefore, the "sustainable" or long-term dependable yield of the Atlantic City 800-foot sand aquifer has been exceeded by present demand. The water resources of the aquifer are essentially being "mined" (USGS, 1990).

If not for the relatively large distances between the existing pumping centers and the saltfront off Atlantic City and southern Cape May, the users of this supply would be faced with the option of seeking costly alternative supplies within a much sooner timeframe. If left unrestricted, however, the distance between pumping centers and the landward-migrating saltfront will continue to decrease. Eventually, the aquifer will not be widely available for future use once saltwater intrusion finally affects these pumping centers. Consequently, it would be prudent for municipalities and other major users of the aquifer to initiate a series of proactive management actions to ensure the long-term integrity of this valuable source of drinking water.

New wells should not be located within close proximity of the advancing saltfront. As discussed above, historical analysis showed that the rate of movement of the saltfront advanced northerly at an average rate of 154 feet per year between 1958 and 1971 when Wildwood was withdrawing water from the Atlantic City 800-foot sand aquifer near where the saltfront was located at that time (USGS, 1992). When compared to the model results above, this analysis demonstrates that the rate of intrusion is greatly influenced by the proximity of the pumping center. Wells located in close proximity to the saltwater front will likely accelerate intrusion. While wells that are distant from the saltfront contribute to saltwater intrusion over the long-term, new wells located in close proximity to the landward-migrating saltfront, or to substantially increasing pumpage from existing wells at these locations will accelerate the rate of salt water intrusion into the aquifer. Since wells in other confined aquifers in these locations influence ground water levels in the Atlantic City 800-foot sand aquifer, it would also be expedient to restrict withdrawals from these aquifers.

As described earlier, the recharge area for the Atlantic City 800-foot sand aquifer may be in contact with the brackish water in Barnegat Bay. Development in the Southern Barnegat Bay watershed has been substantial and is projected to be significant in the decades to come. Thus, there is some possibility that this watershed's deeper wells can be vulnerable to saltwater intrusion. This concern should be addressed in the comprehensive water supply plan recommended by this report. Until this plan is complete, it would be prudent to comprehensively scrutinize new wells, and the expansion of existing wells, in this watershed. Additional monitoring wells would be appropriate to address this uncertainty.

Regarding the effects of saltwater intrusion in the Atlantic City 800-foot sand aquifer in southern Cape May County that can be attributed to Egg Harbor, Galloway and Hamilton townships, it will be necessary to estimate the percentage of overall water that these three towns withdraw from the aquifer or aquifers that are hydraulically connected to the aquifer. Approximately 19 MGD are presently withdrawn from the Atlantic City 800-foot sand aquifer. Egg Harbor, Galloway and Hamilton townships withdraw approximately 2.2 MGD from the aquifer, or about 12 percent of the total. Based on this simple assessment and the distance from the landward-migrating saltfront, the three municipalities represent a relatively small fraction of the overall saltwater intrusion problem.

Based on the fact that saltwater intrusion is a long-term problem, in conjunction with the notion that withdrawals from the water table aquifer are believed to be impacting aquatic resources in the Great Egg Harbor and Mullica River watersheds presently, NJDEP should consider prioritizing the Atlantic City 800-foot sand aquifer for new potable (essential use) withdrawals until the comprehensive investigation is completed for the region. As suggested above, however, NJDEP should restrict the use of this aquifer if new withdrawals will result in a significant acceleration of saltwater intrusion. This recommendation is elaborated upon in Section 7.0.

5.4 WATER QUALITY

Concerns have been raised regarding water quality impairment in the water table aquifer as a result of increasing development. Water quality in a watershed typically decreases as development increases (USGS, 2000). Emphasis must be placed on protecting the Kirkwood-Cohansey water table aquifer, since much of the Southeastern New Jersey Study Area population is reliant on this source for their drinking water supply. Since the Atlantic City 800-foot sand aquifer is confined, it is generally protected from human activities at the surface.

The water table aquifers in the watersheds of the Southeastern New Jersey Study Area are, generally, of good quality other than naturally occurring iron and manganese, which often exceed secondary drinking water standards. However, some samples taken from wells show elevated levels of nitrate and lead that are often associated with urban areas and agricultural lands (Watt and Johnson, 1990 and 1992). In addition, elevated concentrations of lead have been found in wells located along major roadways in the region, and purgeable organic compounds that exceed drinking water standards have been detected near landfills (McAuley, Paulachok, Clark, Zapecza and Barringer, 1990). The water table aquifer has low pH values that have little buffering capacity. This low buffering capacity makes the water very sensitive to changes brought on by the effects of human activities. Further, there are more than 500 ground water pollution cases in Cape May, Atlantic and Ocean counties (Berry, 1995). As the region grows, the potential for further impairment of the water table aquifer as a result of human activities will undoubtedly also increase. Last there is growing concern of radionuclides and some naturally occurring metals in the region; these will need to be examined in the comprehensive plan recommended in this report.

Water from surface supplies may serve as a future alternative for the region (see Section 7.2, Potential Alternatives). Several initiatives have been undertaken over the last several years that are showing that these supplies may be threatened unless actions are taken in the near future. Also, unless the surface water supplies of the region are adequately protected, its drinking water supplies from the water table aquifer may be susceptible to contamination from human activities. Pumping ground water from the water table aquifer can decrease ground water levels and cause water to flow from streams into aquifers, bringing contaminants along with it (USGS, 2000).

The U.S. Environmental Protection Agency (EPA) requires reports from the NJDEP that describe water quality impairments of the surface and ground water quality standards. The report, the New Jersey 2002 Integrated Water Quality Monitoring and Assessment Report, identifies which of the State's waterways do not meet its Surface Water Quality Standards or the designated downstream uses. Sub-List 5 of that report identifies surface waters and ground water in the State that do not attain water quality standards. The list presents data on all water quality limited waters, and prioritizes waterways with respect to scheduling investigations on total daily maximum load (TMDL) on the rivers, streams or lakes. This list represents a collective monitoring effort by government agencies including the USGS, the Pinelands Commission, the NJDEP - Bureau of Monitoring Management, and the Health Departments of Atlantic, Gloucester and Cape May counties. Data from the NJDEP's 2002 Integrated List provides a revealing glimpse of the ways in which land uses reflect water quality conditions.

Designated uses within the Southeastern New Jersey Study Area vary with the classification of a water body. In the study area these designated uses can be for either primary and secondary contact recreation; maintenance, migration and propagation of the natural and established aquatic biota; for the Pinelands waters water supply for cranberry bogs and other agricultural uses; for the maintenance, migration and propagation of the natural and established biota indigenous to this unique ecological system; public potable water supply after such treatment as required by law or regulation; industrial and agricultural water supply; or in tidewaters for the protection of shellfish harvesting, migration of diadromous fish, maintenance of wildlife, secondary contact recreation or maintenance and migration of fish populations or other uses (NJDEP, 1994, Surface Water Quality Standards).

The Integrated List shows that as the streams in the Southeastern New Jersey Study Area leave the Pinelands, different parameters collected at monitoring stations suggest non-attainment for aquatic life. Other monitoring data suggest that pH, copper, nitrate, fecal coliform or temperature are negatively affecting other uses. County Health Department monitoring sites are showing that fecal coliform near lakes or beaches are not allowing recreational uses to be met. These, along with the NJDEP Shellfish/Finfish Monitoring Program findings, help reveal the quality of rivers as they enter estuaries. Data such as low dissolved oxygen levels, high nutrient concentrations, high concentrations of sediments or high levels of metals in fish or shellfish provide an "early warning" of problems in the estuaries for recreational/fishing users, for aquatic life, or preventing algal blooms. In the tidal rivers, using dissolved oxygen measurements, the Jumping River, tidal Patcong Creek and the Middle River within the Great Egg Harbor River watershed were found to be non-supportive of aquatic life use. This condition is attributed to upstream population growth (NJDEP, 2002, Integrated List).

The NJDEP's bio-monitoring program is also engaged in determining whether surface waters are impaired, moderately impaired or not impaired, based on conditions of the aquatic macro-invertebrate community. Conditions that might affect a stream reach may include the configuration of the stream itself (shallowness, whether the substrate is composed of mud, silt, or rocks, its stream bank conditions, tree cover, the presence of a stormwater outfall or various other man made structures). These conditions can be altered by development within the watershed, either through stormwater additions to peak flows or base flow subtraction through surface and ground water withdrawals. Specific results are presented in the State of New Jersey's 2002 Integrated List of Waterbodies for the Southeastern New Jersey Study Area.

In addition, streamflow depletion is known to negatively affect the biological resources of a stream (Kecskes, 2000). Significantly changing the natural flow regime and the consequent alteration to water depth is likely to affect the region's aquatic resources by modifying their critical habitat for various life stages and cycles, passage routes, temperature requirements, freshwater/brackish water requirements, food sources, seasonal propagation and migration habits, and other important features. By affecting these aquatic resources, other land-based wildlife that depends on these aquatic resources are likely to be affected. Further, the changes in water quality associated with the substantial depletive and consumptive water uses are likely to further aggravate these conditions.

Significant depletive and consumptive water uses can substantially alter flow regimes and the timing of these regimes. Naturally low stream flows during the summer and fall can evolve to extremely low stream flow during this period, as depletive and consumptive water uses increase. Further, these extreme low flows will increase in their duration as these types of water uses increase over time. Lastly, the impervious cover associated with development characterized by substantial depletive and consumptive water uses leads to excessive flooding, further harming critical aquatic habitats (Kecskes, 2000).

Streams with modest drainage areas may go dry during extreme drought. During the recent drought of 2001-2002, streams that never dried up did for the first time. As discussed above, many streams experienced new record low flows during this extreme, but relatively short-term, drought. The majority of these streams are characterized by substantial depletive and consumptive water uses within their watersheds.

It is unknown how long it takes the indigenous aquatic resources that inhabit streams that experience the most severe drought effects to recover. A factor that would need to be considered is that New Jersey has experienced some level of drought (drought warning or drought emergency), on average, every three years during the past two decades. Limited research has shown that native resources may in fact no longer be self-sustaining in watersheds most hard-hit by repeated drought. Ultimate recovery from a series of moderate droughts is aborted by a subsequent extreme drought. It is likely that only those aquatic resources that can tolerate these extreme low stream flows will successfully adapt and propagate under these conditions. This phenomenon is inclined to trigger a chain of events where the aquatic resources become less diverse throughout the entire stream segment; these streams are prone to be solely inhabited by limited number of drought-tolerant species.

Additionally, these conditions can be exacerbated by other development impacts including: water quality impairment, siltation, increased nutrient loads and algal growth, habitat intrusions such as road crossings, wetlands dewatering, increased erosion of channels and banks due to increasing flooding peaks, stream temperature alteration due to tree removal and stormwater, etc. The response of the aquatic ecology to the above effects requires a better understanding of the cause-response relationship. To begin to answer these questions, the NJDEP is currently exploring minimum streamflows needed to support various aquatic resources. The findings should be included in the comprehensive water supply plan that this report recommends as a way to determine the amount of water that can be depletively and consumptively used in Southeastern New Jersey Study Area.

Below are findings of other efforts that summarize water quality conditions in the Southeastern New Jersey Study Area.

5.4.1 Great Egg Harbor

In 1998 the EPA generated an index of watershed indicators that rated the Great Egg Harbor with an overall watershed score of 4, with 1 being the best and 6 being the worst. This score results from combining 15 indicators of watershed conditions and vulnerability. It was decided that the Great Egg Harbor fell into this category because:

> Point sources of pollutants such as inadequately treated wastewater from sewage treatment plants, and non-point sources such as stormwater run-off, residential waste from pesticides and fertilizers, business wastes, antiquated septic systems, agricultural run-off, and wetland loss are largely responsible for the poor water quality. (www.greategg.org/CMP_page_5.htm).

The Egg Harbor River at Berlin was identified as severely impaired for aquatic life support. Various other monitoring sites along the river revealed either impairment of the reach for primary contact recreation, and aquatic life support based on high pH, fecal coliform, total inorganic nitrogen, total phosphorus, heavy metals (including arsenic, cadmium, chromium, lead and mercury) and instances of mercury suggesting that fish consumption be limited.

5.4.2 Mullica River

A report published in 2001 demonstrated that water quality conditions for the Mullica River stream sites were clearly related to conditions within the watershed. Through agreements with the Pinelands Commission, the USGS collected water quality data at 18 Mullica River Basin sites from October 1995 through September 1998. The data revealed “strong relationships between developed land and upland agriculture in a drainage basin and pH, specific conductance, calcium, magnesium, and chloride” which describe 84 to 89 percent of the variability in the water quality variables. Compared to developed land, agricultural land accounted for a greater percentage of the variation in calcium and magnesium concentrations, while developed land explained 84 percent of the variability in chloride concentrations.

5.4.3 Southern Barnegat Bay

The status of the Barnegat Bay tributaries and the overall estuary appears to be linked to the temporal changes in land use within the watershed (Institute of Marine and Coastal Sciences, Rutgers The State University, The Scientific Characterization of the Barnegat Bay-Little Egg Harbor Estuary and Watershed). The high levels of nutrient runoff from residential and agricultural users affect the aquatic system. Barnegat Bay was added to the National Estuary Program in 1995. The report summary concluded that:

- Most of the freshwater inflow to the Barnegat Bay – Little Egg Harbor estuary is ground water that either discharges to streams that flow into the estuary or that seeps directly to the estuary;
- The quality of the shallow ground water in the Kirkwood-Cohansey aquifer system in the watershed is potentially an important determinant of the quality of freshwater inflow and water quality consistent loadings;
- Primary production in the estuary is nutrient-limited, particlarly with respect to nitrogen, and therefore freshwater nitroten loads are a particular concern;
- Nitrogen in surface water discharge to the estuary probably contributed ~50 percent of the freshwater load, whereass ~39 percent may be contributed by direct atmospheric deposition and ~11 percent by direct ground water disharge;
- Results of other studies in the New Jersey Coastal Plain have indicated "a strong relation between land use and nitrate concentration in the unconfined Kirkwood-Cohansey aquifer system;"
- During water years 1986 to 1995, trends were positive for pH, specific conductance, and total nitrate plus nitrite and ammonia;
- The highest surface water total nitrogen yields were from Wrangel Brook, Toms River and Mill Creek basins; and
- The highest total ammonia yields were from Mill Creek, Toms River and Oyster Creek Basins.

The USGS, Pinelands Commission and NJDEP collected surface water quality data at 43 stations throughout the watershed. It was found that the instream concentration of nutrients, sulfate and other inorganic constituents appears to be related to the intensity of development in the areas of contributing drainage upstream of the surface water sites. Streams draining more developed areas have higher concentrations of nitrogen, as well as higher values of specific conductance and pH.

The NJDEP's Source Water Assessment Program (SWAP) will soon be completed. The SWAP will estimate the susceptibility of the region's surface and ground drinking water supplies to potential contamination sources within their source waters. The source waters of all public water supplies were recently delineated and are available. Managing development and its potential impacts to these source waters is a fundamental component of the SWAP. It will be essential that the region's stakeholders participate in this initiative. Until these efforts are actually effectuated, however, stakeholders should comprehensively scrutinize proposed development activities for the potential impact to local drinking water supplies. The NJDEP intends to play a major role in assisting local towns in the protection of their drinking water supplies. This should include enhanced protection of Atlantic City's reservoirs.

Some preliminary SWAP findings regarding public wells in the Southeastern New Jersey Study Area may serve as a "forewarning" for its purveyors and those who use these drinking water supplies. It is well known that intense land use can lead to contamination of ground water supplies in water table aquifers. As part of the SWAP, land use trends between 1970 and 1995 were tracked in all of the Tier 1 well head protection zones of New Jersey's public wells. This effort is showing that the Tier 1 zone of several wells in the region, including some in Egg Harbor, Galloway and Hamilton townships, are being encroached upon by urban land uses. Tier 1 zones of some wells that were characterized in 1970 as being predominantly in forest-type lands have evolved into significant urban-type development patterns. This land use evolution could be to the detriment of the drinking water supply of some wells in the Southeastern New Jersey Study Area. It will be paramount to initiate land development plans to protect these drinking water supplies.

6.0 CONCLUSIONS

The NJDEP has concluded that the water supplies that Egg Harbor, Galloway and Hamilton Townships share with the Southeastern New Jersey Study Area faces several short- and long-term challenges, and that planning, management and regulatory actions implemented now would allay significantly more serious actions in the future (see Section 7.0, Recommendations).

6.1 MAJOR FINDINGS

In brief, the NJDEP has concluded the following:

- The various water resources of the Southeastern New Jersey Study Area are fundamentally interconnected. Land use and water supply decisions made in one part of the region can affect the water resources of another part of the region. Decisions that can affect water resources are currently made on an individual, piecemeal basis. Essentially, all users of water in the region are "sharing" the same resource. An approach that integrates water supply, wastewater, water quality, and ecosystem protection and restoration with "Intelligent Growth" land use planning and management is a prerequisite to ensure sustainable resources in the region. A piecemeal approach will not successfully meet this objective.
- The region is expected to undergo substantial growth during the upcoming decades. Preliminary projections made in this report estimate that the population of the region would grow from 557,424 (2000) to 895,535 in the year 2050. Water demand in the region is projected to grow from about 195.0 million gallons a day (MGD) to about 305.0 MGD by the year 2050. Substantial portions of overall demand are for agricultural, commercial, recreational, and residential irrigation purposes (referred to as non-essential, non-potable uses). For the most part, these uses have been increasing in the region. In addition, significant amounts of water are used in the region's homes and businesses, converted to wastewater and discharged to the ocean. Very little water that is withdrawn is returned back into the freshwater resources of the Southeastern New Jersey Study Area. This factor is the fundamental problem affecting the water resources of the region.
- The population of Egg Harbor, Galloway and Hamilton townships is tentatively projected to grow from 82,434 (2000) to 179,822 in the year 2050, which would represent nearly half of the total population of Atlantic County and more than 20 percent of the population of the region. Demand is projected to increase from 26

MGD to 59 MGD. If this demand is actually realized, it would represent 20 percent of the entire region's future demand. Substantial portions of overall demand are exported or used for irrigation purposes and thus not returned to the source supply. Egg Harbor Township has by far the most water withdrawn.

- Several of the water resources in the Southeastern New Jersey Study Area are threatened by current water withdrawals or are projected to be threatened based on anticipated water demand. The principal reason these resources are, or will be, threatened is the large amounts of water that are withdrawn and not "recycled" back into them. These threatened resources meet the criteria for designation as an Area of Critical Water Supply Concern, as provided in N.J.A.C. 7:19-8.2.
- As a whole the Southeastern New Jersey Study Area has a current water supply planning deficit of about 46 MGD based on present water availability planning thresholds; this is projected to increase to 160 MGD by Year 2050. The Mullica River and Great Egg Harbor River watersheds are experiencing substantial current planning deficits, while the Southern Barnegat Bay and Cape May Coastal watersheds are projected to experience a deficit in the next few decades. Withdrawals from Egg Harbor, Galloway and Hamilton townships are consuming almost all available water in the Great Egg Harbor watershed. If the threshold were apportioned on a county basis, these three towns are presently withdrawing more water than is available to Atlantic County from the Great Egg Harbor watershed.
- Surface water withdrawals and wells pumping from the Kirkwood-Cohansey water table aquifer in the above watersheds are resulting in local and/or regional streamflow reductions during the summer and fall, especially when the region is experiencing drought. Left unabated, these stresses will worsen. Many of the streams and rivers, and the ground water systems that "feed" these streams and rivers in the region, experienced historical lows during the recent drought. This is a result of both the drought and the influence of pumping. Increases in impervious cover as well as the inducement of water from the water table aquifers as a result of pumpage from the deeper confined aquifers may further be exacerbating these reductions.
- Based on the amount of withdrawals from certain wells in relation to the size of the upstream drainage area or their locations near coastal and wetland areas, it is likely that sensitive in-stream and estuarine aquatic resources in the Southeastern New Jersey Study Area are presently being impaired to some degree. This implies that the dependable (or sustainable) yield of this resource is being currently exceeded. Increases from these existing withdrawals and new withdrawals will worsen these conditions. Watershed water budgets being developed by the NJDEP will shortly identify where water withdrawals are specifically exceeding thresholds that are protective of aquatic resources.
- Withdrawals from the Kirkwood-Cohansey water table aquifer to meet the growing demands in Egg Harbor, Galloway and Hamilton townships are likely contributing to the above phenomenon, based on the amounts of water withdrawn.
- Since current and projected withdrawals from streams and the water table aquifer within these watersheds are likely leading to adverse conditions, it would be wise to

immediately take proactive water supply management steps. Emphasis should be place on water conservation.

- Increases in withdrawals from the deep Atlantic City 800-foot sand confined aquifer throughout the region are resulting in a "mining" effect on the water resource. In essence, the dependable (or sustainable) yield of the aquifer has already been exceeded. Ground water pressure levels throughout the aquifer have continuously declined as a result of increased pumpage over the decades.[9]

- On average, ground water pressure levels have been declining one to two feet annually in the Atlantic City 800-foot sand aquifer. The most recent measurements show that pressure levels are now more than 100 feet below sea level in the Atlantic City area, and the cone of depression, where water pressure levels are well below sea level, stretches far into Cape May and Ocean counties. This has resulted in a reversal in the direction of ground water flow; fresh ground water is now being replaced by saltwater. Consequently, saltwater is slowly migrating toward wells on the barrier islands. Wells in southern Cape May County will be affected before wells in the Atlantic City Study Area. While it will be several decades before saltwater affects the Cape May County wells, these conditions are presumptive evidence that demand is exceeding availability. It would be prudent to begin reducing non-essential demand from this supply and develop a long-term plan to cope with imminent, but distant in the future, saltwater intrusion. However, in the short-term it may be prudent for new withdrawals to use this aquifer than the water table aquifer, since current withdrawals from the latter are presently impacting aquatic resources. Due to limited data, it is unknown at this time when wells located along the barrier islands in Ocean County would be placed at risk.

- Withdrawals from the Atlantic City 800-foot sand aquifer or aquifers hydraulically interconnected with this aquifer by Egg Harbor, Galloway and Hamilton townships represent about 12 percent of all withdrawals from this aquifer. While not critical, the townships' withdrawals from this aquifer thus play a role in saltwater intrusion in southern Cape May County.

- Pollutant sources associated with development are threatening the quality of the region's surface water and water table aquifer supplies. Unless efforts are undertaken to control these sources of pollution, the threat will grow as the region continues to develop. Urban-type development is encroaching into well head protection areas of several of the region's drinking water supplies, including those of Egg Harbor, Galloway and Hamilton townships. This type of development can result in these supplies being vulnerable to contamination.

Based on these conclusions, there is the need to take numerous actions over the coming years in order to ensure a safe, plentiful supply of drinking water for the future. The conclusions reached in this report strongly suggest that innovative and integrated solutions will be required that can only be successfully implemented through substantial

[9] Ground water pressure levels (or the potentiometric surface) refers to the elevation or level that water in a confined aquifer would rise if a well were installed into it. The potential for saltwater intrusion increases when ground water pressures are substantially below sea level in close proximity to the freshwater/saltwater interface in a confined aquifer in a coastal area.

involvement and cooperation of those having a stake in the water resources of the region. Many of the estimates and conclusions made in this report are tentative, due to the limited data that was available, and will require verification in the recommended comprehensive water supply plan.

6.1 UNCERTAINTIES

There are some uncertainties that will need to be addressed during the selection of long-term strategies, alternative water supplies, and when they will need to be implemented during the development of the comprehensive water supply plan. First, the USGS models estimated saltwater movement in the Atlantic City 800-foot sand aquifer based solely on advective (non-dispersive) flow and homogeneous aquifer conditions. If zones of high permeability exist in the aquifer, especially in southern Cape May County and the southern half of Ocean County, brackish water may travel much faster toward pumping centers. This possibility is lessened with regard to the Atlantic City area pumping centers because of the lower permeability that characterizes the aquifer beneath the ocean floor where the salt front is presently located, and the sheer distance between the pumping centers and the salt front.

Second, the USGS models assume that brackish water exists at specific locations (Veronin, Spitz and McAuley, 1994). The location of the salt front in Ocean County is somewhat unclear. It would be prudent to install onshore observation wells in the Barnegat Bay area, as well as in other strategic locations, to provide this information and refine the USGS models to serve as an early warning system. The chloride and ground water pressure level data, and an interpretation of the data, should be distributed every few years to the users of the Atlantic City 800-foot sand aquifer and the watershed stakeholders for informational purposes, as well as for water supply strategy implementation. Further, additional stream discharge gauging stations may be necessary in the Mullica/Great Egg Harbor river watersheds to more accurately estimate streamflow diminution as a result of depletive ground water withdrawals.

Third, the regional model employed future demand projections that are presumptive and can be significantly higher or lower in the future. As this report shows, population and water demand projections can be significantly different, even when developed a few years apart. Further, the models used 50-year planning demands to estimate the migration of the salt front in southern Cape May County that is less than four miles to the south of the nearest existing pumping center (Stone Harbor). Growth will obviously occur beyond this planning period, as well as an increase in the rate of the salt front movement toward public wells. It is recommended that various population/demand projections be made and that these projections be used to estimate migration of the salt front toward pumping centers over the long-term, as well as to provide a schedule for implementation of alternative water supplies. These projections should include those for a 100-year planning period, or maximum build-out based on Intelligent Growth plans.

Fourth, no estimates were made of when saltwater may be induced in the Barnegat Bay area where the freshwater aquifer is in contact with brackish waters and where several Ocean County wells are located on the barrier island. Future assessment should be made. As described below, that assessment should also include the effects that wells in other confined aquifers that influence ground water pressure levels in the Atlantic City 800-

foot sand aquifer, such as the Rio Grande aquifer, may have on it. The mainland area is projected to undergo substantial development in future decades. Several confined aquifers in Ocean County are presently restricted due to overuse. Some municipalities may envision using the Atlantic City 800-foot sand or other hydraulically connected aquifers to meet their future needs in southern Ocean and southern Burlington counties. Thus, estimates of saltwater intrusion should be made in the near future, and they should take these secondary effects into consideration. Consideration should also be given to including the Atlantic Coastal watershed in future planning efforts, since it shares the Atlantic City 800-foot sand aquifers with the users of the region.

Fifth, based on the rate of withdrawal from several wells withdrawing water from the Kirkwood-Cohansey water table aquifer in comparison to the upstream drainage area, there is anecdotal evidence that impairment to aquatic resources may be occurring. Further, there are several wells in close proximity to coastal brackish water. Based on the rate of withdrawal from these wells in comparison to the proximity of these brackish waters, the potential exists that inducement of these waters may affect aquatic resources, as well as result in abandonment of the wells due to salt water intrusion as demand increases. The water budgets and other NJDEP initiatives will provide insight to this phenomenon.

Lastly, the planning thresholds employed in the 1996 Plan, as well as in this report, are just that – planning thresholds. Both reports recommend that these thresholds be verified with more comprehensive analysis. It is for that reason that a comprehensive water supply plan is recommended for the region. The magnitude of depletive and consumptive water uses in the Great Egg Harbor and Mullica River watersheds (and to a lesser degree in the Southern Barnegat Bay watershed), in conjunction with the continuous decline in ground water levels in the Atlantic City 800-foot sand aquifer, is highly suggestive that these resources are over-extended. These circumstances warrant the interim “no net increase in non-potable water use” strategy until that comprehensive investigation is completed. To maintain the status quo would likely lead to additional damage to the region’s water resources, and require the implementation of an even more rigorous alternative water supply plan.

7.0 RECOMMENDATIONS

The above findings represent formidable challenges. The NJDEP intends to take a two-prong approach to alleviate the above described water supply conditions in the Southeastern New Jersey Study Area. This approach consists of an interim and a long-term strategy. The long-term approach consists of the development and implementation of a comprehensive water supply plan for the region that will be integrated into an overall Intelligent Growth management plan. Since it will take several years to develop and effectuate the water supply plan, in conjunction with the fact that development will continue in this fast-growing region, an interim strategy is needed to ensure that existing water supply problems are not exacerbated.

7.1 INTERIM STRATEGY

Since the comprehensive plan will not be completed until 2006 or 2007, the NJDEP will coordinate with the stakeholders of the region to implement an interim strategy. This strategy should consist of the following:

- The primary goal of the strategy should be to not allow for adverse water resource conditions to be further exacerbated. This interim strategy would be coordinated by the NJDEP with stakeholder participation. It would consist of a strategy where there would be “no-net-increase” in water use from threatened water resources for new or expanded non-potable water supplies in the Southeastern New Jersey Study Area. For every new or expanded increase in non-potable water use from a threatened water resource, the objective would be to either use other sources such as reclaimed water or to obtain a commensurate reduction from an existing non-potable water use from the same resource.

- NJDEP will investigate the possibility of allowing an existing non-potable water user to sell their allocation upon switching to an alternate water supply such as reclaimed water. The sale of an allocation would help offset increased infrastructure and treatment costs associated with water reclamation.

- NJDEP will also work closely with the region’s stakeholders to implement a range of water conservation measures for existing holders of water allocation permits as a means of preserving the potable supply. Measures such as rainfall and soil moisture sensors for irrigation systems, days when irrigation is not allowed, drought tolerant landscaping, aquifer recharge augmentation practices, etc. will be evaluated by NJDEP in coordination with the stakeholders.

- While the comprehensive water supply plan is being developed, it is recommended that new or expanded potable withdrawals should be required to use only the deeper confined aquifers unless saltwater intrusion will be accelerated in zones prone to this phenomenon. As discussed above, excessive withdrawals from the region’s water table aquifers are likely presently impacting the aquatic resources, while the Atlantic City 800-foot sand aquifer is not expected to be affected by saltwater intrusion until well into the future. This interim strategy is considered to be a reasonable tradeoff for the next three or four years. As described below, these new users will need to participate in the comprehensive plan recommended by this report since they are likely to be affected. In light of this potential, NJDEP should also encourage future potable supply applicants to consider novel approaches to conserving the supply such as: 1) to conjunctively use the deeper confined aquifer when streamflow conditions are low and the water table aquifer when streamflow conditions are higher, 2) aquifer storage and recovery, and 3) flood skimming of surface water supplies (including recharging aquifers with surface water). The NJDEP would establish the minimum passing flow for when withdrawals from the water table aquifer or surface water supply must cease. This minimum flow will be based on the amount of streamflow depletion that has already occurred.

- New or expanded potable supply withdrawals that return the vast majority of water used back to the same source in the general vicinity of the withdrawal should be encouraged during the interim period. For example, a new subdivision that withdraws water on-site from the water table aquifer and discharges its treated wastewater on-site to the same aquifer would meet the intent of this strategy, as long as it institutes a rigorous conservation program. NJDEP should coordinate with region stakeholders as part of the wastewater management process to assess appropriate opportunities to implement this strategy.

- Increasing ground water recharge in excess of that required by the NJDEP's Stormwater Management Rules should be encouraged. NJDEP should coordinate with region stakeholders to assess appropriate opportunities to implement this strategy. The Pinelands Commission has been requiring new development to recharge aquifers for more than two decades.
- During this interim period, new Atlantic City 800-foot sand wells will be restricted near the saltfront, since its landward migration would be significantly accelerated by increases in withdrawals at these locations. New wells in other confined aquifers in these areas that contribute to ground water level pressure declines near the saltfront in the Atlantic City 800-foot sand aquifer will also be restricted.

There are currently additional studies that are ongoing, including the development of watershed water budgets and ecological streamflow objectives. When available, the results of these studies will better inform the interim strategy presented above. The NJDEP intends to revisit and adjust the conclusions and recommended actions of this report as better information becomes available.

7.2 GENERAL LONG-TERM STRATEGY

Because of the limited number of traditional water supply alternatives available to the region (i.e., lack of reservoir potential), and the fact that existing supplies are interactively related, innovative approaches and institutional arrangements will be required to preempt the threat of saltwater intrusion into the Atlantic City 800-foot sand aquifer. Concurrent approaches and arrangements regarding the use of the Kirkwood-Cohansey aquifer must be developed to address streamflow depletion, wetlands dewatering, degradation of natural resources, and the migration of saltwater into the region's estuaries as a result of potentially excessive use. Since Egg Harbor, Galloway and Hamilton townships share these supplies with those in the region, these municipalities are urged to participate in developing and implementing these approaches.

Since the region's future population will continue to be dependent on these water supplies for decades to come, efforts to protect the quality of present and future resources from impairment will be of the utmost importance. In order to ensure long-term sustainability, water quality protection programs (e.g., well head protection, aquifer protection, SWAP, nonpoint source pollution control, etc.,) should accompany water supply alternatives that are being considered. In addition, protection of private wells will need to be equally considered when devising water quality protection programs. Contamination of numerous domestic wells will only place additional stress on existing regional water supplies and hasten the need for alternatives.

Given these circumstances, water supply management should be integrated into an approach that "links" Intelligent Growth land use planning, water supply, wastewater management and the protection of ecological resources, as well as incorporation into a comprehensive water supply plan. Prioritizing and implementing integrated solutions to address the causes of water resource degradation and misuse is necessary. This approach emphasizes the involvement of all affected stakeholders and stresses the need for teamwork at the State, county and local levels to attain the greatest improvements and protection of the available resources. Inherent in this approach is the need to consider an institutional entity or entities to facilitate such a comprehensive plan and ensure that it is implemented.

Key elements of this approach for the Southeastern New Jersey Study Area include: 1) inventorying all current zoning from the applicable municipal master plans (once Intelligent Growth planning has been finalized), 2) estimating water demand that would be required under the zoning, 3) estimating when demand will exceed availability, 4) developing a range of water supply alternatives to meet demand when it has exceeded availability, and 5) selecting the appropriate alternative(s).[10] In the event that the alternatives are concluded to be excessively costly or otherwise impractical, zoning can be revised by the region's stakeholders so as to result in a decrease in demand. The use of environmental/land use models will facilitate these analyses, and be instrumental in selecting the most practical alternatives.

It will, however, take some period of time to develop and implement Intelligent Growth/water resource management plans for the region. Maintaining the "status quo" as development proceeds during this period will exacerbate many of the problems discussed above, and result in greater difficulty and more costly means in addressing them. Consequently, it is imperative that local land use decision-making officials exercise their statutory authority to ensure that new development will not threaten local water supplies. The NJDEP should simultaneously employ its statutory and regulatory authority to ensure that development proposals under its purview (proposed water allocations, wastewater management plans, water and sewer expansions, etc.) do not further aggravate conditions described in this plan.

The next subsection describes the interim and long-term steps that the NJDEP and Southeastern New Jersey Study Area stakeholders should take to adequately address the region's water supply problems. Assuming these steps are taken, this report provides a description of potential implementation strategies and a range of possible water supply alternatives and related efforts that could be considered, once Intelligent Growth/water resource planning has been initiated to ensure future water availability.

7.2.1 Quantifying Water Supply and Demand

Prior to considering long-term possible water supply alternatives, the NJDEP, in coordination with the watershed stakeholders, should more precisely define and quantify the dependable or sustainable yields of the Southeastern New Jersey Study Area's existing water resources. Unless this step is completed, an evaluation of which water supply alternatives are required and when they should be implemented will be unreliable.

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[10] A similar methodology should be used to estimate the effects of zoning on the quality of water supplies and local surface and ground water systems, and on aquatic resources, and to plan to minimize these effects.

The dependable yield of a ground water resource is the long-term water yield sustainable during projected future conditions without creating undesirable effects.[11] Among the effects that need to be considered are saltwater intrusion, streamflow depletion, conditions during drought, impacts to other uses, and impairment to ecological resources. When streamflow depletion that is a result of excessive ground water withdrawals is a consideration, meeting minimum stream passing flows during a repetition of the most severe drought of record will need to be evaluated. Existing models will be valuable in this process.

The NJDEP has initiated the development of the next New Jersey Statewide Water Supply Plan. This plan will define the dependable yield of aquifer systems. The region's stakeholders should assess whether they wish to employ a more conservative definition of yield for the ground water resources of the Southeastern New Jersey Study Area. The NJDEP will update the region's stakeholders of the yield recommendations that are being made so that the stakeholders can consider their appropriateness for the region.

As previously discussed, there is the concern that excessive withdrawals from the water table aquifers making up the Mullica River, Great Egg Harbor River and Southern Barnegat Bay watersheds are resulting, or will in the future result, in intolerable streamflow depletion. This phenomenon may be complicated by agricultural surface water and water table aquifer diversions and storage activities in the Mullica River watershed as well as the effects of pumpage of the water table aquifer for potable supply within the watershed, and pumpage from the Atlantic City 800-foot sand aquifer throughout the Southeastern New Jersey Study Area. Also, pumpage from the deeper, confined aquifer induces water movement from the water table aquifer.

Consequently, it is recommended that a two-step process be undertaken to quantify. The first step is to accurately quantify water withdrawals in the watersheds. The NJDEP, in cooperation with the USGS, the NJ Department of Agriculture and the watershed stakeholders should coordinate a definitive measurement of both watersheds' average and peak agricultural and other, including potable, uses including when and where major withdrawals and discharges take place, and the depletive/consumptive nature of those uses. The second step is to quantify the withdrawal's likely effects (seasonal, including drought) on streamflow and other water-related features. This assessment should be conducted at the sub-watershed level (either HUC 14 or HUC 11), in order that local effects can be more accurately estimated.

The NJDEP is in the process of developing water budgets for all of the State's watersheds and the amount of water necessary to support freshwater aquatic resources. These budgets will estimate how much water enters a watershed, how much is depletively and consumptively removed from the watershed as a whole, and how much water flows from the watershed. The latter will be compared to how much water is required to maintain and protect natural aquatic resources within the watershed (i.e., the dependable or sustainable yield of the watershed's surface water and water table aquifer resources). These efforts should be completed in 2004. The comprehensive water supply plan recommended by this report should expand on this initiative by evaluating local effects from individual withdrawals.

[11] See N.J.A.C. 7:19-4.2.

If information gathered from the above verifies that present or future withdrawals may result in undesirable effects on streamflow, natural ecological systems, wetlands and/or saltwater intrusion into the freshwater portion of the rivers' estuarine systems, then the NJDEP, in coordination with the watershed stakeholders, should initiate a comprehensive investigation of alternative water supplies and strategies to preclude these impacts, as described below.

Based on the Southeastern New Jersey Study Area's growth potential, water demand will continue to grow during and beyond the 50-year planning period, and the salt front will continue to accelerate as demand beyond the planning period increases. Consequently, it is suggested that various scenarios that project demand well beyond the current planning period (including build-out based on Intelligent Growth zoning) be incorporated into either the existing models, or into more recently developed models that are known to be more accurate, in order to more precisely estimate a time frame for alternative water supply implementation. As described earlier, the dependable yield definition that will be recommended in the next New Jersey Statewide Water Supply Plan should serve as the basis for the implementation plan. The NJDEP and the watershed stakeholders should then determine which of the water supply strategies described in the remainder of this section to implement as a solution to the long-term saltwater intrusion problem and any streamflow reduction impacts.

7.2.2 Potential Long-Term Implementation Strategies – Atlantic City 800-Foot Sand Aquifer

There are various implementation strategies that can be pursued to mitigate saltwater intrusion in the Atlantic City 800-foot sand aquifer. These strategies range from the very conservative where a "fixed" demand is selected (i.e., the amount of withdrawals capable of maintaining the long-term dependable yield) and alternatives implemented in the near future that would allow for uninterrupted use of the aquifer, to the more liberal where demand would be mostly uncontrolled but alternatives would be implemented at specific "trigger" points. In all strategies, the objective would be to establish a plan to maintain or stabilize ground water pressure levels above sea level near the salt front. The very conservative strategy would be to stabilize the salt front near its current location, while the more liberal would allow for the continued advancement of the salt front to a predetermined inland location. Some of these strategies are discussed below.

The first implementation strategy is the most conservative. Once the model has been updated, this strategy would be to reduce current withdrawals from the Atlantic City 800-foot sand aquifer to a level where the salt front is stabilized at particular locations in order to ensure a fully sustainable supply. Essentially, this strategy would be similar to that used by the NJDEP in managing the State's reservoirs whereby demand is not allowed to exceed the safe yield of the reservoir.

In this case the model(s) would determine the optimum demand that would stabilize the salt front at locations that would allow for the continued, but reduced, perennial use of the aquifer, and regional or sub-regional (and equally sustainable) water supplies would be implemented over the next decade or so to compensate for the reductions as well as meet future demand. Until the model estimates this optimum maximum demand, it is unknown whether water conservation (alone) would be capable of stabilizing the salt front where an existing pumping center would not be at risk until some future point in time (when future demand "negated" the reductions obtained through conservation).

The second somewhat less conservative implementation strategy would be to "freeze" current and near-term water demand to ensure that saltwater intrusion would be deferred well into the future, and to begin over the next couple of decades to implement a plan to meet future water supply needs. When the salt front approaches existing wells in the future as a result of current pumpage, withdrawals from existing wells would be reduced (and some near the salt front may need to be abandoned), and a regional water supply alternative would be implemented that would stabilize the salt front at locations that do not threaten those wells. This strategy assumes that ground water pressure levels will rebound above sea level at specified locations some time after the reductions in usage occur (similar to the rebound in Critical Water Supply Areas 1 and 2). An aggressive water conservation and water reclamation program for existing users of the aquifer would obviously defer intrusion and, thereby, increase the time until the regional alternative would be needed.

The third strategy would be to allow unrestricted use of <u>existing</u> withdrawals from the Atlantic City 800-foot sand aquifer until the salt front approaches those wells proximal to the salt front. Prior to these wells being at direct risk, a predetermined regional water supply alternative would be implemented that is capable of both stabilizing the salt front through major usage reductions and meeting future demand. Existing wells would only serve presently approved franchise areas. No new wells would be allowed to be drilled into the aquifer to meet the demands of new service areas; new demand would be met by sustainable regional or sub-regional water supply alternatives. As in the case above, water conservation and water reclamation would defer the timeframe until the regional plan would need to be executed.

The fourth strategy would be to allow unabated withdrawals from the aquifer and to implement a predetermined regional water supply plan when the salt front nears wells in close proximity to the salt front. The only wells that would not be permitted would be those proposed between the present location of the salt front and existing pumping centers (see below). The regional alternative would be of a magnitude capable of meeting the sizable usage reduction necessary to stabilize the salt front at Stone Harbor in Cape May County and Harvey Cedars in Ocean County, as well as to meet future demand needs. Again, conservation and water reclamation would postpone the time when the regional plan would be put in to place.

As implied in the implementation strategies above, the longer the delay in taking action, the larger (and more costly) the regional water supply alternative that will be required. This certainty will have to be considered by the NJDEP and the watershed stakeholders when selecting a strategy. Also, the NJDEP, affected water supply purveyors and other potential users should consider a restriction whereby no new withdrawals from the Atlantic City 800-foot sand aquifer would be proposed in (freshwater) areas in close proximity to the existing salt front. Any new withdrawals at these locations would likely substantially accelerate the inland migration of the salt front toward existing wells by further depressing water pressure levels. It would be wise for municipalities and other users to agree to restrict future withdrawals from the aquifer in "zones" down gradient (generally south) of the most southerly existing pumping center (Stone Harbor) and up gradient (generally north) of the most northerly center (Harvey Cedars), which is near saltwater in the recharge area. The same strategy should apply to new wells in other confined aquifers, where withdrawals from these aquifers can affect ground water pressure levels near the salt front in the Atlantic City 800-foot sand aquifer. It would be prudent to implement water conservation and water reclamation programs for those pumping centers nearest the salt front.

Equally inferred in the above strategy alternatives is the possible restriction of new wells being drilled into the Atlantic City 800-foot sand on the rapidly growing mainland. New wells will undoubtedly cause ground water pressure levels to further decline and consequently prematurely trigger when the selected alternative will need to be implemented. If this restriction is implemented, caution must be exercised that all future wells are not constructed in the water table aquifer, thereby exacerbating possible intolerable streamflow reductions. In addition, since the sustainable yield of the Atlantic City 800-foot sand aquifer has been found to currently be exceeded, the NJDEP should consider a suspension on any new non-essential (non-potable) water allocations from this resource. Non-essential uses should be directed to use reclaimed water, whenever available. If reclamation is substantially impractical, efforts should be made for new users to coordinate with existing users where the latter would reduce its water use in the amount needed by the new user or other supplies that are experiencing surpluses should be used.

7.2.2a. Monitoring Needs

There will be the need to develop a formal monitoring network that serves to continuously observe the movement of the salt front in the Atlantic City 800-foot sand aquifer, to trigger when alternatives should be implemented, and to verify and calibrate the ground water models in the future. As described below, the present regional monitoring network is inadequate for these purposes. A new observation well is needed in the Barnegat Bay area to detect movement in the saltwater from the bay into the aquifer's outcrop. Further discussions with the NJGS and the USGS should occur to determine other network needs for the aquifer.

In addition, there may be a need to install additional stream gauging stations and observation wells in the Great Egg Harbor and Mullica River (and Atlantic Coastal, if integrated into the region) watersheds to more accurately estimate the effects of depletive water uses from the Kirkwood-Cohansey aquifer and surface water diversions on streamflow. These needs will be discussed by the above agencies.

7.2.3 Potential Long-Term Implementation Strategies – Kirkwood Cohansey Sand Aquifer

An implementation strategy for the Kirkwood-Cohansey water table aquifer should be developed simultaneously with that for the Atlantic City 800-foot sand aquifer, if the water budgets conclude that withdrawals from this aquifer and direct surface water diversions are resulting in undesirable effects. Based on the diversion rates of several withdrawals from the water table aquifer in contrast to the drainage area of the upstream watersheds, there is a likelihood that some withdrawals are already affecting aquatic resources in specific stream reaches. Surface water diversions associated with the agricultural industry may also be problematic. In addition, some withdrawals are located in close proximity to saltwater in the estuaries. The potential for saltwater intrusion into the wells as well as the effects on freshwater-dependent aquatic resources will need to be investigated.

For withdrawals that are found to be currently negatively affecting aquatic resources, two possible options are available to the NJDEP. One would be denial of any applications to the NJDEP to directly or indirectly expand demand from these withdrawals, largely through denial of requests for expansion of sewer and water systems, water allocation renewals, activities under the purview of the Coastal Area Facilities Review Act, etc. This option can be taken at any time, when NJDEP has determined that an increase in water use will cause intolerable effects.

The second option could be the designation of an Area of Critical Water Supply Concern for the watershed or sub-watershed where the present withdrawals are cumulatively causing intolerable effects (N.J.A.C. 7:19-8.1 et seq.). This process includes:

- Public notice and hearing of the designation;
- Demonstration that the designation is warranted through the use of a water supply availability study (the water budget project);
- An estimation of future water supply needs (the 1996 Plan's population/water demand projections); and
- An identification of appropriate and reasonable alternative water supply management strategies, including but not limited to water conservation and substitution of alternative water supplies.

Once the NJDEP completes the water budgets for the watersheds of the region, and estimates if undesirable impacts are occurring or will occur as demand increases, it will coordinate with the stakeholders to develop and implement the appropriate water supply alternative plan. In the event that this coordination is unsuccessful, NJDEP will then determine the appropriate action.

Below is a brief description of the long-term water supply options that are available to defer or entirely eliminate the threat of saltwater intrusion in the Atlantic City 800-foot sand aquifer and the effects of depletive and consumptive water uses from the water table aquifer and surface waters in the Great Egg Harbor River, Mullica River and Southern Barnegat Bay watersheds. These options should be considered individually and in combination with each other. When options are being considered, the hydrologic models should be used to determine if they would meet the goals of the selected strategy.

7.2.4 Water Conservation Plan

Because the severity of the water supply problem in the Southeastern New Jersey Study Area is anticipated to grow over time, the need to maximize available water supplies is essential. As discussed above, water conservation will defer the time when a major regional water supply alternative will be needed to stabilize the salt front in the Atlantic City 800-foot sand aquifer to protect existing pumping centers. Water conservation can also reduce the undesirable effects associated with streamflow depletion, should this phenomenon indeed be verified in the Great Egg Harbor River, Mullica River and Southern Barnegat Bay watersheds. Water conservation planning is actively being conducted in Atlantic County by the ACUA and in Cape May County by the Board of Chosen Freeholders. These plans, as well as conservation initiatives developed by purveyors and municipalities, should be substantially expanded to include all of the region's present and future users of the Atlantic City 800-foot sand aquifer and the Kirkwood-Cohansey water table aquifer.

It is envisioned that a water conservation plan for the Southeastern New Jersey Study Area will emphasize reducing outdoor water use, primarily in the form of residential and commercial lawn watering, and agricultural irrigation. It is estimated that one home with a one-acre lawn that employs an automatic sprinkler system will use 1,000 to 2,000 gallons per day during the growing season. These amounts represent three to six times the amount of water used indoors. The typical golf course uses 200,000 to 400,000 gallons of water per day. Non-Agricultural irrigation increases in water such as that for golf courses, commercial irrigation, etc., have been steadily and significantly increasing in all four watersheds of the region. Agricultural activities in the Mullica River watershed are by far the largest users of water, withdrawing on average approximately 90 MGD (Hoffman and Lieberman, NJDEP, 2000).[12]

Water conservation, as well as those applicable water supply strategies identified below, should be most rigorous for those municipalities using the Atlantic City 800-foot sand aquifer that are the closest to the advancing salt front. Increasing water pressure levels at those locations would reduce the rate of intrusion. This is not to minimize the need to implement a comprehensive water conservation plan throughout the Southeastern New Jersey Study Area. All users of the aquifer contribute to the advancement of the salt front. Consequently, a reduction in water use via conservation would increase ground water pressure levels throughout the aquifer. Area stakeholders should evaluate institutional/financial arrangements that can facilitate this strategy, as well as that needed to implement a conservation program for all other users in the Southeastern New Jersey Study Area.

Reducing the amount of water used for residential/commercial irrigation can play a significant role in deferring saltwater intrusion and minimizing the effects of streamflow depletion. In many municipalities in Cape May, Atlantic and Ocean counties, summertime peak water use in several municipalities is twice or more that of wintertime use. Combined, peak purveyor demand is 135 MGD in these three counties (NJDEP, 1996). In addition, unaccounted-for water (water that leaks from distribution systems, that is used from hydrants to fight fires, etc.) is significant, ranging from seven to 34 percent (NJDEP, 1966). Unaccounted-for water represents 14 MGD of overall water use. If the majority of water that is lost in this manner is from leaking distribution systems, repair of these systems might be instrumental in "buying time" in implementing needed alternative water supplies.

[12] Much of the agricultural withdrawals for the cranberry and blueberry industries are returned to the watershed during the fall months, and thus may not result in a substantial reduction to streamflow. This will need to be verified in a follow-up assessment.

For insight on the potential for water conservation to attenuate saltwater intrusion in the Atlantic City 800-foot sand aquifer, the experiences in Critical Water Supply Areas 1 and 2 provide excellent examples of how reductions in withdrawals from aquifers can result in a sustainable supply. In the 1980s ground water pressure levels along the southern Raritan Bay areas and the northern half of Gloucester County declined to levels that either resulted in the abandonment of public and industrial wells because of advancing saltwater, or the imminent threat of the loss of wells. The NJDEP designated the affected aquifers as Critical Water Supplies and required withdrawal reductions ranging from 23 to 50 percent. Alternative (and relatively costly) water supplies were implemented in the 1990s and ground water pressure levels have risen as much as 50 feet or more in some of the regulated aquifers (USGS, 2001), thereby increasing the long-term integrity of these supplies. It is presumed that similar benefits can be accomplished in the region through the development and implementation of a substantially less costly water conservation strategy. A rigorous conservation program is likely to readily parallel the withdrawal reductions required in Critical Water Supply Areas 1 and 2.

As various water conservation plans are considered, USGS models for the Atlantic City 800-foot sand aquifer and water budgets developed by the NJDEP can be employed to estimate how effective these plans would be in deferring saltwater intrusion and reducing streamflow reductions. It is anticipated that conservation will likely be a major component of the overall water supply plan for the Southeastern New Jersey Study Area. The NJDEP and watershed stakeholders will need to devise means of ensuring that municipal water departments and purveyors are not adversely affected by comprehensive conservation efforts, since these entities can be financially affected by curtailing water use. In addition, agricultural interests will need to be considered if conservation includes this industry.

7.2.5 Water Reclamation/Recycling

This initiative is primarily directed at two modes of water reclamation, namely: 1) using wastewater for non-potable activities such as irrigation and industrial cooling, and 2) locating wastewater discharges in order to maintain adequate supplies of freshwater in streams and other appropriate water bodies. Water reclamation for non-potable purposes could potentially be a key component of a water conservation strategy. For example, using treated wastewater directly from regional plants that discharge to the ocean, or tapping wastewater conveyance infrastructure and subsequently treating it for irrigation purposes or electrical generation could substantially reduce demand from the Atlantic City 800-foot sand aquifer. Water reclamation could also potentially reduce the effects associated with streamflow depletion caused by excessive withdrawals from the water table aquifer in the Great Egg Harbor River, Mullica River and Southern Barnegat Bay watersheds. The NJDEP has recently initiated a program to encourage water reclamation (NJDEP, 2003).

There are substantial amounts of treated wastewater available for beneficial reuse in the Southeastern New Jersey Study Area. Based on NJDEP's wastewater monitoring reports Atlantic, Cape May County and Southern Ocean County discharge to the ocean on average 27.75 MGD, 18.25 MGD and 6.96 MGD, respectively.

For designated Intelligent Growth areas, streamflow depletion should not be significant if water is withdrawn from the water table aquifer at optimal locations (i.e., not near ecologically sensitive areas or in headwater streams) and discharged to either surface water or ground water via a sewage treatment plant or community on-site system in the same approximate area after adequate treatment, and if the sewer service area implements a water conservation plan. New plants and on-site systems could be managed by existing regional municipal utility authorities to maximize economies of scale, and nonpoint source pollution controls should be implemented to ensure suitable water quality. Of course, caution should be exercised to ensure that local streams are not overwhelmed with treated wastewater.

If this option were selected, it should be well planned as part of the Intelligent Growth/resource management approach. This alternative should be seriously evaluated as a means of reducing future demand on the Atlantic City 800-foot sand aquifer and the Kirkwood-Cohansey aquifer. If all new growth on the mainland implemented this option, and significant water conservation savings were realized by existing barrier island users of the aquifer, saltwater intrusion would likely be staved off well into the future. The same would apply by future users of the water table aquifer; if all new users implemented this strategy, the problem of streamflow depletion would not be further exacerbated. As discussed earlier, various reclamation options can be tested via the ground water computer models and the water budgets that are currently being developed.

7.2.6 Domestic Wells/Septic Systems

The use of domestic wells that withdraw their supplies from the water table aquifer in combination with individual septic systems (versus public water supplies and centralized sewers) and water conservation on adequately sized building lots in anticipated low density Intelligent Growth areas on the mainland would preclude some of the stress on regional water supplies that is expected in the future. This option, employed in conjunction with using the water table aquifer/local wastewater discharge alternative for planned Intelligent Growth centers on the mainland (see Section 6.6), would especially reduce the future stress that the Atlantic City 800-foot sand aquifer and the water table aquifer are anticipated to experience in the future, if demand is left unrestrained.

7.2.7 Seasonal Conjunctive Use – Confined and Water Table Aquifers

This option is considered to be the foremost alternative water supply for coastal New Jersey by attenuating both the effects of excessive withdrawals and consequent saltwater intrusion in confined aquifers and streamflow reductions caused by inordinate withdrawals from water table aquifers. Continuous (and increases in) withdrawals from the Atlantic City 800-foot sand aquifer have resulted in a “mining” effect upon the aquifer. And, the detrimental effects of depletive and consumptive withdrawals from the water table aquifer are likely affecting aquatic resources in some stream reaches in the Southeastern New Jersey Study Area during the naturally low streamflow months of summer and fall. Future depletive and consumptive withdrawals will likely exacerbate these effects. During the winter and spring months, however, streamflow is often three to five times that of the summer and fall months. During periods of heavy precipitation, streamflow is often several times that of annual mean streamflow.

Thus, withdrawals from the water table aquifer or the direct diversion of surface water easterly of the Pinelands boundary during the winter and spring may be a significant seasonal supplemental water supply should withdrawals from the Atlantic City 800-foot sand aquifer be restricted. During this period, water pressure levels in the Atlantic City 800-foot sand aquifer would likely rise as a result of a reduction in demand, thereby retarding the advance of saltwater. Similarly, if withdrawals from the water table aquifer are found to impair natural resources during the summer and fall months, the Atlantic City 800-foot sand aquifer might be the more appropriate supply to be using during this period. The USGS ground water flow model, and the NJDEP water budgets/flow goals project can be employed to estimate the advantages of this strategy.

If properly designed, the environmental impacts associated with this water supply alternative would likely be minor. If ground water withdrawals from the water table aquifer were required to cease toward the end of higher streamflow periods, ground water levels would likely recover before the more (environmentally) critical low streamflow periods. The minimum passing flow, when water table aquifer withdrawals would cease, would need to consider the current effects of withdrawals from the water table aquifer. And, if properly sited, other environmental impacts can be attenuated (e.g., wetlands, critical wildlife habitat). Water treatment costs should be minimal if withdrawal sites are carefully selected. If streamflow is directly withdrawn, and withdrawals are strictly limited to specific high flow conditions, the environmental effects should be relatively insignificant. Nevertheless, the potential impacts would have to be carefully evaluated if seasonal conjunctive use is to be pursued as an alternative water supply. It is recommended that this option be assessed early on; delays will only reduce the number of potential sites as the region develops, and land restrictions and water quality concerns reduce their availability.

It is also recommended that confined aquifers (e.g., the Piney Point and Rio Grand aquifers) in the region, other than the Atlantic City 800-foot sand aquifer, be evaluated for potential future seasonal use. While not to be considered major water supplies, these confined aquifers could serve as alternatives in the event that the water table aquifer is stressed by excessive diversions during the summer and fall months. Only those aquifers not closely connected to the Atlantic City 800-foot sand aquifer should be considered.

7.2.8 Seasonal Artificial Recharge/Aquifer Storage and Recovery

Artificial recharge of ground water from the water table aquifer or surface waters that are "skimmed" during peak flow periods into the Atlantic City 800-foot sand aquifer conceptually appears to be a substantial alternative water supply that should be evaluated. Diverting a relatively small fraction of peak streamflow or ground water from the water table aquifer during the winter and fall months at the most optimum downstream location(s), and recharging that water into the Atlantic City 800-foot sand aquifer, could potentially both increase ground water pressure levels to a point that the salt front might be retarded from further advancing, and allow the aquifer to act like a reservoir for peak demand periods. Recharging wells closest to the salt front would probably offer the greatest benefit, since it would raise water pressure levels at these critical locations. This alternative deserves serious inquiry.

Since this alternative would be operated in a seasonal conjunctive use mode, the environmental impacts are suspected to be minor, since only a fraction of peak flow would be diverted. In addition, the surface water intake(s) could conceivably be a "run-of-the-river" (non-dam) structure. Pipeline and retrofitting wells may, however, be costly and water quality might be somewhat problematic. Nevertheless, because of the large quantities of water that theoretically can be made available to the fast-growing region by implementing this alternative, as well as the advantages that sustainable water supplies offer, it would be beneficial to evaluate this option. As in the above option, it should be evaluated in the near future to ensure the availability of favorable sites.

7.2.9 Reservoir Planning

The reservoirs operated by the ACMUA conceptually can reduce demand from the Atlantic City 800-foot sand aquifer or the water table aquifer. The safe yield of these reservoirs is 9.3 MGD; however, approximately 3 MGD are used on average. Thus, present demand from the Atlantic City 800-foot sand aquifer can be reduced about a third if the reservoir's total yield were utilized. It should be noted that the yield of this reservoir system (9.3 MGD) is that amount of water available during drought. During periods of higher flows, substantially more water is available. Since much of the infrastructure already exists, this option should seriously be evaluated.

In addition, a potential 1,800-acre reservoir site capable of storing 3 billion gallons of water has been identified on the South River in the Great Egg Harbor River (Havens and Everson, 1980). The site is located in the Pinelands National Reserve, but outside of the State designated Pinelands Area. This abbreviated assessment estimated that if a reservoir were constructed at this site, it could yield up to 69 MGD. Thus, if the reservoir were constructed, present demand from the Atlantic City 800-foot sand aquifer can potentially be reduced to a level where the salt front would be permanently stabilized for decades to come and relief provided in the Great Egg Harbor River and Mullica River watersheds should intolerable streamflow depletion conditions be confirmed. The project's 1980 estimated cost was $32 million. Based on the quantity of water that the project can potentially make available, this option should be seriously assessed. It is unknown at this time if the South River reservoir site is occupied by environmentally sensitive features or significant development - both of which could pose major concerns.

7.2.10 Optimized Well Locations

Previous ground water investigations concluded that there were signficant advantages in locating wells at redistributed locations and at optimized rates in the Atlantic City 800-foot sand aquifer (USGS, 1990 and 1992). The rationale is to locate new wells at sites that are distant from the saltfront and for pumpage rates to be maintained at rates that allow ground water levels to remain above sea level at locations near the saltfront. Theoretically, this strategy results in a sustainable supply. However, this strategy may not allow for an adequate supply to meet the Southeastern New Jersey Study Area's water supply needs in the future. In addition, it will be relatively expensive to abandon existing wells and site new wells in distant locations. Nevertheless, existing ground water flow simulation models should be used to explore this potential alternative.

In addition, strategically locating new wells in the water table aquifer as far downstream along larger streams and rivers is an alternative that deserves serious consideration. The rationale is that a large withdrawal from the water table aquifer in the lower portion of a watershed would remove a large fraction of streamflow, as compared to the same withdrawal in the upper portion of the same watershed. As described above, optimally located withdrawals in the water table aquifer can provide substantial amounts of water during the winter and spring without causing severe impacts to other uses and users.

Lastly, strategically locating new wells along the divides of watersheds and distant from any headwater streams, and timing their withdrawal rates, may be promising (USGS, 2001). This option would allow significant amounts of water to be withdrawn from wells near a larger stream or river, and shifted to wells along the divide during periods of low streamflow. The rationale of this option is that the effects of the well withdrawals along the divide will not be felt for several months. By that time, flow in the applicable stream or river should have recovered as the effects of evapo-transpiration decline during the colder months.

Both of the above alternative water table aquifer options should be evaluated if the water budget project concludes that certain withdrawals are, or will in the future, cause undesirable impacts to natural resources.

7.2.11 Desalination

The desalination process is capable of turning brackish water or actual seawater to potable water. While considered an expensive mode of water treatment, it is used in arid areas or areas where freshwater supplies are limited such as coastal Florida. Cape May City, at the very end of Cape May County, has recently constructed a relatively small desalination plant due to imminent saltwater intrusion. It is not envisioned that desalination will be a high priority to meet the Southeastern New Jersey Study Area's's water supply needs at this time due to the high costs, especially the operating costs. The regional and sub-regional alternatives described above are thought to be more cost-effective. Once future demand approaches the sustainable yields of these alternatives, however, desalination facilities may be the sole available alternative.

7.3 WATER QUALITY PROTECTION INITIATIVES

Based on the large and growing population of the Southeastern New Jersey Study Area, and its reliance on ground water, greater emphasis will need to be placed on aquifer protection strategies. Further, in the event that surface water will play a larger role in meeting future demand, watershed-based pollution control strategies will be essential. Both strategies will need to integrate land use planning and management activities with water-related activities to achieve sustainable water supplies and to protect the region's ecosystems. Among the strategies that the NJDEP and the watershed stakeholders should emphasize are provided below.

7.3.1 Well Head Protection

The primary objective of well head protection is to minimize the risk to public and domestic water table aquifer wells through appropriate protection measures ranging from education and pollution source prohibition to acquisition of land near public wells. These measures emphasize the delineated geographic area (well head protection area) that contributes water to a well over a specified time period. Several well head protection programs have been initiated in the Southeastern New Jersey Study Area. It is recommended that these programs be expanded. Consideration should also be given to pre-locating future water table aquifer wells to preclude the impacts associated with development.

Amendments to the federal 1996 Safe Drinking Water Act required that the well head protection area of each public well in the State be delineated, potential pollution sources identified, and the source supply ranked with respect to its potential to be contaminated. These tasks are expected to be completed by Year 2003 as part of the NJDEP's SWAP Program. Then, protection plans will be developed as part of the watershed management process for those wells determined to be vulnerable to the inventoried contamination sources. Since these plans will take a few years to develop and be implemented, local land use planners should adopt precautionary measures when evaluating development plans within well head protection areas. These areas have been delineated and are available to local planners.

7.3.2 Aquifer Recharge Area Protection

Land use and related activities can affect both the quality and quantity of water that is recharged to an aquifer. Water that infiltrates into a ground water recharge area serves as a water supply, provides base flow in streams, and retards saltwater from entering the Southeastern New Jersey Study Area's aquifers and estuaries. Based on the growing population of the region, the potential for contamination and reduced ground water recharge is a concern. As such, aquifer recharge area protection should be a major component of the water supply plan for the Southeastern New Jersey Study Area. The primary purpose of the aquifer recharge area initiative should focus on ensuring that land uses and their related activities are adequately planned and managed to allow for natural or enhanced quantities of suitable quality water to be recharged to the region's aquifers. Aquifer recharge area delineation, pollutant source control, and stormwater and septic system management should be key components of the initiative. In addition, the acquisition of critical aquifer recharge areas and means of funding such acquisitions should be considered.

The recharge areas of the Southeastern New Jersey Study Area have been delineated and the rates of recharge have been estimated by the NJDEP. As in the case of well head protection areas, local land use planners should adopt precautionary measures when evaluating development plans within aquifer recharge areas, especially those with the higher values. The recently proposed Stormwater Management Rule should be helpful in this regard.

7.3.3 Surface Water Nonpoint Source Protection

Other than the ACMUA's reservoirs, the Southeastern New Jersey Study Area is primarily dependent upon ground water for its potable supply. However, since surface water may play a greater role in meeting future demand, surface water nonpoint source control programs may grow in importance in the decades to come. These programs focus on land use planning and stormwater management to ensure that land uses will not adversely affect the quality and quantity of surface water supplies and other beneficial uses (e.g., ecosystems, recreation, commercial fisheries). Similar to well head and aquifer recharge area protection efforts, emphasis is placed on identifying individual and cumulative pollutant sources and implementing controls on those sources through pollution prevention, buffer zones, and land acquisition in critical water supply watersheds. Critical ecological resources should be delineated so that they can properly be safeguarded from the effects of nonpoint sources of pollution. In addition, wells that are located adjacent to streams can induce surface water into them. Where this potential exists, surface water quality protection needs to be emphasized. The recently proposed Stormwater Management Rule will also be helpful in meeting the objectives of protecting stream water quality, as well as ensuring that stream baseflow is maintained.

7.3.4 Redesignation of Streams, Watersheds, Well Head and Aquifer Protection Areas

The upgrading of stream reaches and watersheds that serve as current or future water supplies, or those that are inhabited by sensitive natural resources, to more protective surface water quality designations is a tool available to the NJDEP and watershed stakeholders. Specifically, consideration to upgrading to Category One (C1) status would provide substantial benefit to these important water bodies. C1 provides additional protection to exceptional water supplies and ecosystems by not allowing activities that would result in a measurable change to water quality. The NJDEP recently proposed that ACMUA's Doughty Pond reservoir on Absecon Creek be designated as C1. Other exceptional water bodies should now be considered for this extra measure of water quality protection. Watershed stakeholders (including municipal and county officials) may petition the NJDEP for redesignation of specific streams and watersheds by following the protocol outlined in the Surface Water Quality Standards (N.J.A.C. 7:9B et seq.).

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APPENDIX A

MUNICIPALITIES AND MUNICIPAL YEAR 2000 POPULATIONS WITHIN THE SOUTHEASTERN NEW JERSEY STUDY AREA

MUNICIPALITIES IN MULLICA WATERSHED			
			Year 2000
ATLANTIC CO.			
001	00100	Absecon city	7,638
001	02080	Atlantic City city	40,517
001	07810	Brigantine city	12,594
001	20290	Egg Harbor township	30,726
001	20350	Egg Harbor City city	4,545
001	25560	Galloway township	31,209
001	29430	Hammonton town	12,604
001	40530	Linwood city	7,172
001	41370	Longport borough	1,054
001	43890	Margate City	8,193
001	49410	Mullica township	5,912
001	52950	Northfield city	7,725
001	59640	Pleasantville city	19,012
001	60600	Port Republic city	1,037
001	68430	Somers Point city	11,614
001	75620	Ventnor City city	12,910
		Sub-total	214,462
BURLINGTON CO.			
005	03370	Bass River township	1,510
005	66810	Shamong township	6,462
005	72060	Tabernacle township	7,170
005	77150	Washington township	621
005	82420	Woodland township	1,170
		Sub-total	16,933
CAMDEN CO.			
007	12550	Chesilhurst borough	1,520
007	77630	Waterford township	10,494
		Sub-total	12,014
		TOTAL	243,409

MUNICIPALITIES IN GREAT EGG HARBOR WATERSHED			
			Year 2000
ATLANTIC CO.			
001	08680	Buena borough	3,873
001	08710	Buena Vista township	7,436
001	15160	Corbin City city	468
001	21870	Estell Manor city	1,585
001	23940	Folsom borough	1,972
001	29280	Hamilton township	20,499
001	80330	Weymouth township	2,257
		Sub-total	38,090
CAMDEN CO.			
007	05470	Berlin township	5,290
007	81740	Winslow township	34,611
		Sub-total	39,901
GLOUCESTER CO.			
015	47250	Monroe township	28,967
		TOTAL	106,958

APPENDIX A (Cont'd)

MUNICIPALITIES IN CAPE MAY WATERSHED			
			Year 2000
CAPE MAY CO.			
009	02320	Avalon borough	2,143
009	10270	Cape May city	4,034
009	10330	Cape May Point borough	241
009	17560	Dennis township	6,492
009	41610	Lower township	22,945
009	45810	Middle township	16,405
009	53490	North Wildwood city	4,935
009	54360	Ocean City city	15,378
009	66390	Sea Isle City city	2,835
009	71010	Stone Harbor borough	1,128
009	74810	Upper township	12,115
009	78530	West Cape May borough	1,095
009	80210	West Wildwood borough	448
009	81170	Wildwood city	5,436
009	81200	Wildwood Crest borough	3,980
009	81890	Woodbine borough	2,716
		Sub-total	102,326
CUMBERLAND CO.			
011	44580	Maurice River township	6,928
		TOTAL	109,254

MUNICIPALITIES IN SOUTHERN BARNEGAT BAY WATERSHED			
OCEAN CO.			Year 2000
029	03050	Barnegat township	15,270
029	03130	Barnegat Light borough	764
029	03940	Beach Haven borough	1,278
029	18670	Eagleswood township	1,441
029	30390	Harvey Cedars borough	359
029	37380	Lacey township	25,346
029	40560	Little Egg Harbor township	15,945
029	41250	Long Beach township	3,329
029	54300	Ocean township	6,450
029	66480	Seaside Park borough	2,263
029	67110	Ship Bottom borough	1,384
029	70320	Stafford township	22,532
029	71640	Surf City borough	1,442
029	74210	Tuckerton borough	3,517
		TOTAL	101,320